JOURNAL BPA OF THE

Biological Photographic Association

Dedicated to the Science and Techniques
Pertaining to the Photography of All
Things Which Live or Which Have Lived

QUARTERLY OF THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION, INC.

Volume 22, Number 1 February, 1954

JOURNAL *of the* BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

EDITOR • LLOYD E. VARDEN, F.B.P.A., F.P.S.A., F.R.P.S.
Pavelle Color Incorporated 533 West 57th Street New York 19, New York

EDITORIAL BOARD

Dr. Edmond J. Farris, The Wistar Institute, Philadelphia, Pa.
Dr. Arthur W. Proetz, 1010 Beaumont Bldg., St. Louis, Mo.
Dr. Oscar W. Richards, American Optical Company, Southbridge, Mass.
Harris B. Tuttle, 343 State Street, Rochester, N.Y.

OFFICERS OF THE ASSOCIATION

President — Warren Sturgis, Sturgis-Grant Productions, Inc., 322 East 44th Street, New York 17, N.Y.

Vice President — H. Lou Gibson, Eastman Kodak Company, 343 State Street, Rochester 4, N.Y.

Secretary — Jane H. Waters, Pavelle Color Incorporated, 533 W. 57th Street, New York 19, N.Y.

Treasurer — Albert Levin, Photographic Department, Magee Hospital, Pittsburgh 13, Pa.

EDITORIAL POLICY

Manuscripts should be sent to the Editor in legible form, preferably typewritten, double spaced, with wide margins. Tables should be given on separate sheets, each with self explanatory captions. Give references separately, numbered according to reference notations in the manuscript. References should include, where applicable, article or book title, author(s), volume and number or edition, page number(s), publisher, month and year.

Illustrations should accompany manuscript, preferably unmounted. Give legends separately, clearly identified. Illustrations should be of proper dimensions to fit single column, double column or full page of the Journal.

The editors reserve the right to reject manuscripts considered unsuitable. Major alterations of accepted manuscripts will not be made without permission of the author(s).

Special Note: If you have an idea or technique of importance to biological photography and need assistance in preparing a manuscript, write the Editor.

Opinions expressed by authors are not necessarily those of the Biological Photographic Association.
Copyright, 1954, by Biological Photographic Association, Inc.

OFFICIAL PUBLICATION OF THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION, INC.

Published at 733 North Van Buren Street, Milwaukee 2, Wisconsin. Editorial office: 533 West 57th Street, New York 19, N.Y. Entered at the Post Office, Milwaukee, Wisconsin, under the act of March 3, 1879. Subscription price $6.00 per volume; foreign $6.50. Single copies $1.50 in the U.S.A.; foreign $1.65 in U.S.A. funds.

Journal of the Biological Photographic Association Vol. 22, No. 1 February, 1954

Image Distortions with Illumination at Small Angles of Incidence—Part I*

CHARLES HALE

Dominion Museum, Wellington, New Zealand

Introduction

WHEN using the apparatus recently described by the author[1] to photograph small opaque specimens with axial or near-axial light, various kinds of distortion are encountered. As the primary purpose of designing the above apparatus was to control and reduce image distortion, and thereby provide a means for the more accurate representation of opaque biological specimens, the present survey may be regarded as an investigation into the basic optical requirements of such an apparatus. It will be shown that distortion arises from two sources: perspective and illumination, the former kind divisible into distortions within the image of a symmetrically placed specimen, and distortions between specimens at different positions within an image field.

Experience with the camera-illuminant unit indicates that for some reason this technique is more critical than orthodox methods. For instance, asymmetry in the disposition of the specimen within the image field, or inexact alignment of the illuminating beam, produces images that are clearly untrue representations of the original. Such distortions must also exist in photographs made with more oblique light, when they are found in association with shadows and "relief" effects. It is thought that these latter in most cases mask distortions, which pass unnoticed.

The photograph by oblique light is a relief effect of light and shadow (chiaroscuro) which gives an illusion of depth and suggests solidity, that is, the specimen appears in a three-dimensional setting. This kind of photograph is not a pure linear effect but is a combination of linear and relief effects. It might be argued that if we could eliminate the relief component we should be left with a linear effect associated with continuous tone. It was to eliminate relief that the application of vertical illumination optics was investigated in the first place.

Habit has accustomed us to regard the photograph as a combination of two things — the object itself, and light. Even though the "light" were infrared or ultraviolet and invisible to the human eye it was still the same kind of radiation and visible to the camera eye in the same kind of way. Now the visual effect of light is a relation of two opposites — light and no-light, and images formed by light are combinations of light components and shadow components. But drawings which are accepted as exact representations of natural objects may be either combinations of light and shadow components or pure linear effects. The outline drawing can be a

* Received for publication October 23, 1953.

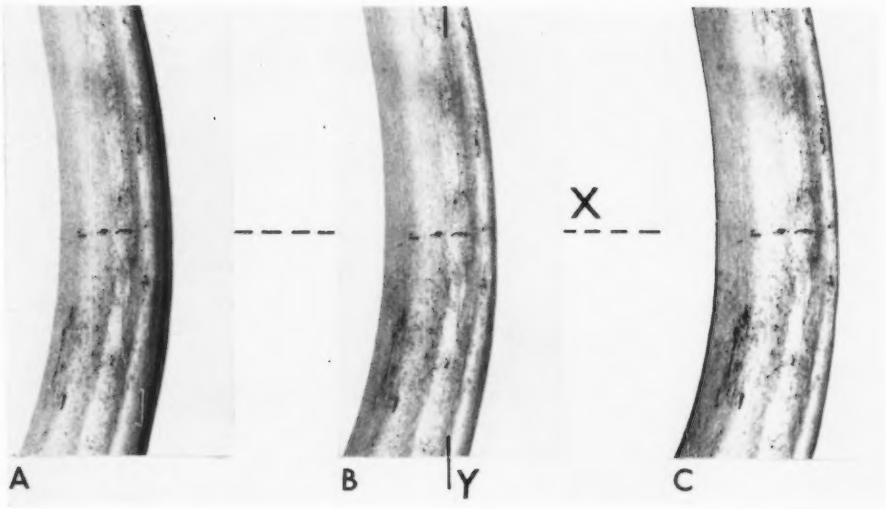


Figure 1. Rib bone photographed at three positions in an image field. Width of specimen at X = 1 cm.

pure linear effect without detriment to its value as an exact representation. In fact, the purity of its linear quality is frequently an asset. It was believed that if the camera could be used to obtain pure linear effects much work that now has to be done by hand could be done by the camera.

Using V.I.*, the result of reducing the shadow component is to clarify the linear effect and this reveals distortions in the "drawing" of the object that normally pass unnoticed. Thus we are left with a linear effect in combination with tone, plus distortions of various kinds. It will be seen that this "tone" element is only a reinforcement of line, for when it is printed out, partially or (occasionally) wholly, the line is left unaffected. It remains to analyze these distortions and seek means of reducing them.

* Vertical Illumination.

Procedure

To provide an image that could be compared with known conditions of perspective and angles of incident light, an image field, distant 33.9 cm from the lens, was axially lit, and in it a specimen was photographed at three positions. The specimen is identical for the three positions A, B and C (Fig. 1), and is part of a rib bone of a sheep. This was afterwards sectioned along the transverse axis X. The profile obtained was then related to a series of rectangles oriented with respect to various angles of incident light (θ). The dimensions of the rectangle for B ($\theta = 0°$), where the specimen is symmetrically disposed about the optical axis of the lens (x = the lateral dimension; y = vertical dimension) is:

$$x/y = 1/1.6$$

Spatial relationships for specimen and image field are given in Figure 2 where X is the background plane and Z the optical axis. The image field, being symmetrical about Z, is a typical setup for V.I. and illustrates the nature and degrees of dis-

tortion normally encountered. For the three positions of the specimen the three images give three series of calculations which may be compared. From such comparisons distortion, as a function of image-field position and angle of incident light, may be better understood.

The basic facts provided by Figure 1 are these: that A and C are equidistant from Z and are, therefore, images of the same specimen formed under identical conditions of perspective. Because the illuminating beam was aligned with Z, A and C are images formed by light at identical angles of incidence. The differences between the images of A and C are caused by the two types of distortion, either separately or in combination, namely, perspective and illumination.

Perspective Distortions

It will be noticed from Figure 2 that the lens-object distance of 31.3 cm is greater than normal. This is accounted for by the preference for long focal length lenses with V.I. and by the fact that the magnification was only 1.35X. Had the image been required to fill the plate used ($3\frac{1}{4}$ in. x $4\frac{1}{4}$ in.) the magnification would have been about 7X. Since foreshortening is greater with shorter focal length lenses, the distortions obtained in Figure 1 would be considerably increased with normal lenses and/or greater magnifications. Since these effects are important, calculated equivalent effects will be given for both normal lenses and normal magnifications for the sake of comparison.

18 cm lens, image 1.35X,
lens-object dist. = 31.3 cm

18 cm lens, image 7X,
lens-object dist. = 20.57 cm

13 cm lens, image 7X,
lens-object dist. = 14.86 cm

The five profiles of the specimen in circumscribed rectangles in Figure 3 illustrate the means used to examine distortions of the image caused by variations of specimen position in the image field. Dealing with (c) first: this gives actual vertical and lateral proportions of the specimen, which also coincide with the proportions of the image formed at this position. The vertical (y) sides of the rectangle repre-

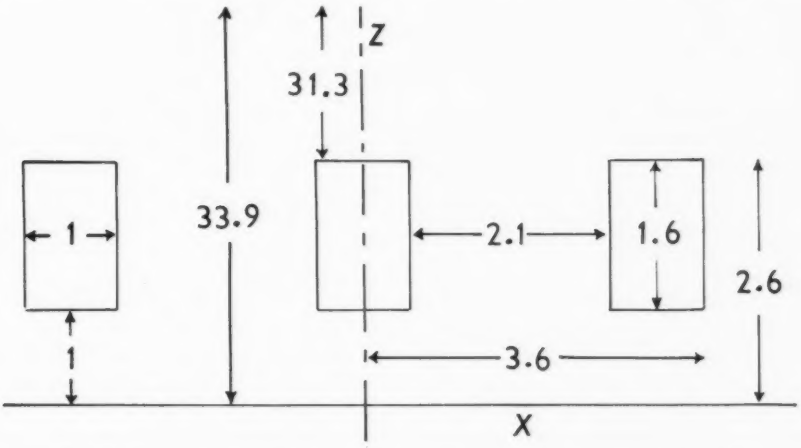


Fig. 2. Distances and dimensions (in centimeters) of specimens, related to background-(X) and optical-(Z) axes.

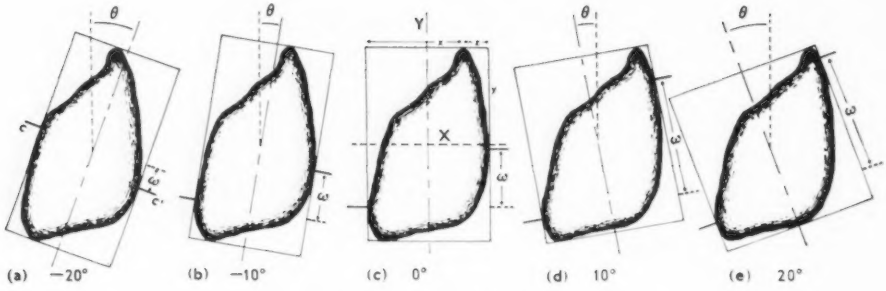


Figure 3. Profiles of the specimen in rectangles orientated to five values of ϕ.

sent edge-forming image rays. These are drawn parallel although in actual fact they converge to the lens. Their convergence is so slight that for purposes of illustration nothing is lost by regarding them as being parallel.

Values of θ for Edge Rays (Figure 3 c)

18 cm lens, 1.35X = 00° 53′ 40″
18 cm lens, 7X = 1° 23′ 26″
13 cm lens, 7X = 1° 55′ 31″

In Figure 3c the ratio *x*:*z* is the ratio of least distortion, since this is the position of maximum symmetry. In other positions (a, b, d, e) *x*:*z* has different values, therefore the image is less symmetrical and more distorted. It will be seen that the amount of distortion increases as θ increases, and that the nature of the distortion varies not only with changes in θ but also with the plus or minus sign of θ. These functions can be shown more clearly by reference to a regular profile, a rectangle of the same *x*:*y* proportions as Figure 3(c).

In Figure 4 we have a rectangle (*x*:*y* = 1:1.6) as profile. The image I is seen to consist of two components, Ix and Iy. For only one value of θ does the image consist wholly of the *x* component ($\theta = 0°$), for all other values of θ the Ix : Iy ratio varies as a function of θ. The proportions of Ix to Iy may be calculated very simply.

Since Ix = $x \cos \theta$, and Iy = $y \sin \theta$,

$$I = x \cos \theta + y \sin \theta$$

The magnitude of the Iy component is the amount by which the image departs from symmetry when I = Ix. So, if D = magnitude of distortion,

$$D = Iy.$$

For a profile placed an equal distance to the other side of the optical axis, D will be the same and the two images will be mirror-images of one another. This might be called symmetrical distortion, since regular profiles equidistant from the optical axis and in the same plane are equally and oppositely distorted.

Can this technique be applied to irregular profiles? Unfortunately not, because the calculations depend on constant values for *x* and *y*, that is: the points at which the edge rays are formed must remain constant for values of θ. These points (*c* and *c*′) while constant for a rectangle are not constant for an irregular profile. In Figure 3, *c* and *c*′ vary irregularly for values of θ by an amount *w*. Values of *w* are given in Table I for values of θ.

As θ changes in value and sign, Figure 3 shows that the *x* and *y* dimensions of the rectangle change also. Since *x* indicates lateral image width and *y* the distance between the nearest and farthest planes of the specimen, it is clear that an image

formed at any position other than the one of symmetry undergoes changes in both its dimensions that are erratic and incalculable, and accordingly such an image can have little significance as a representation.

In Figure 1 the most obvious difference between the images A and C, apart from

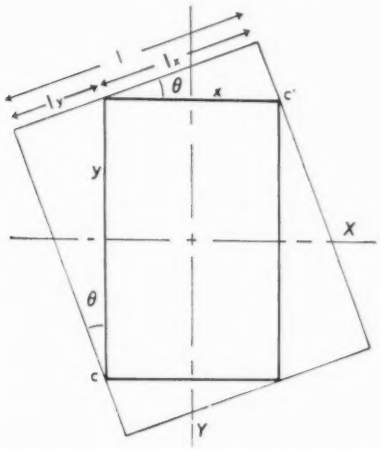


Figure 4. Profile of rectangle showing image image components for $\phi = 20°$.

variation in the x dimension, is in the positioning of the ridge. Clearly A is not a proportional contraction of B, nor C a proportional expansion of B, but both A and C are different complexes of image components—different from one another and from B. If C were proportional to B the ratio x:z would be identical notwithstanding any increase or decrease of the lateral dimension. To illustrate this the graph (Figure 5) shows the x:z ratio plotted as a constant against actual z values taken from the five scale drawings of the profile rectangles in Figure 3. Here the minus values show a greater variation from the normal than the plus, and even where the x dimensions are the same for $\theta = -10°$ and $-20°$ distortion continues to increase.

Distortion for Conditions of Symmetry

When distortion is understood to be the difference in size between images of objects equal in size, symmetrically placed, but at different distances from the lens, this difference derives from the factor w which is the vertical distance between the planes of the objects. In Figure 6 *a* and *b* are two such planes separated by w, and D is the amount of distortion introduced into the image *a* by w. Thus D is a function of w. If *a* and *b* are the planes of two halves of a specimen, then the images of these two halves will be distorted in relation to each other to the extent to which w is a proportion of y. In Figure 3 (a, e) w is shown related to the constant size of the specimen profile which does not give a true reading of D for the points c and c'. It is necessary to find the values of w/y, which are given in Table I. Distortion between c and c' in (a) and (e) is even less than it appears since y is longer for (a) than for (e).

Table I

θ	-30	-20	-15	-10	-5	0	5	10	15	20	30
x	.96	.92	.92	.92	.94	1.00	1.04	1.12	1.21	1.30	1.46
y	1.73	1.75	1.71	1.68	1.64	1.60	1.54	1.51	1.39	1.32	1.24
ω	.23	.21	.15	.40	.36	.48	.88	.92	.92	.96	.91
ω/y	.13	.12	.09	.24	.22	.30	.57	.61	.66	.72	.74

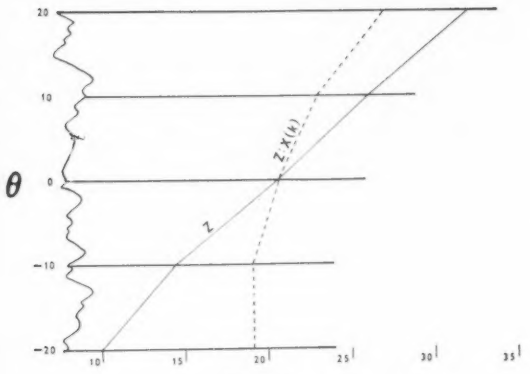


Figure 5. Graph of z as a constant and a variable.

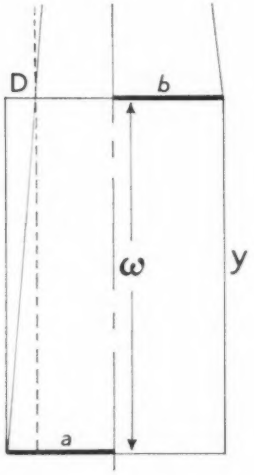


Figure 6. Magnitude of distortion (D), for rectangular profile symmetrically placed, as a function of w.

What relation has the foregoing to the images in Figure 1? The central image ray for A and C subtends the same angle θ at the lens so that we have merely to find θ for one position. Since the two outside rectangles in Figure 2 will be rotated about their centers, it is necessary to use the plane of these centers as one side of a right triangle, with the optical axis as the other. Thus,

$$\tan \theta = \frac{3.6 - .5}{31.3 + .8} = 5^\circ\ 31'\ 02''.$$

Distortion for A will be slightly greater than half that for Figure 3(b), and for C slightly greater than half that for Figure 3(d). Proportional results for shorter focal length lenses and greater magnifications are:

18 cm, 1.35X = 5° 31′ 02″
18 cm, 7X = 8° 14′ 40″
13 cm, 7X = 11° 10′ 00″

Measurements on the original enlarged print show the following relative x dimensions for A, B and C, 2: 2.2: 2.4 cm, which give 0.909: 1: 1.09 compared with the calculated x dimensions in Table I for $\theta = -5^\circ$ and 5° of 0.94 and 1.04.

Summary

The results obtained serve to illustrate the ways in which distortion enters into the formation of an image apart from distortion effects produced by incident light. Since the shapes of specimens are infinitely varied there is no point in making more extensive calculations than serve the purpose of illustrating general laws, because such calculations could only apply to one specimen, whereas the general laws of perspective apply to all specimens.

Reduction of perspective distortion is achieved in the first place by introducing symmetry into the positioning of the specimen before the lens in such a way that edge-forming image rays are equidistant from the optical axis; in the second place by using long focal length lenses and keeping magnification to a minimum consistent with adequate definition.

Reference

Hale, Charles. Description of a Camera Illuminant Unit Employing Vertical Illumination, J.B.P.A., 21:1-10, May (1953).

Journal of the Biological Photographic Association Vol. 22, No. 1 February, 1954

Image Distortions with Illumination at Small Angles of Incidence—Part II*

CHARLES HALE
Dominion Museum, Wellington, New Zealand.

IN the photography of opaque objects the whole of the image is the product of reflected light. The object, then, is essentially a reflector of light. Reflecting surfaces are classified into specular, mixed and diffuse types, examples being: *specular* — silvered glass mirror; *mixed* — smooth white porcelain; *diffuse* — white cartridge paper. The various ways in which light is reflected by these types of surfaces is shown by relating them to given lens and lightsource positions, and to plane and curved surfaces. It is found that minimum distortion is associated with symmetrical conditions of lighting — as is the case with perspective — but that distortion as a function of both lighting and perspective combined may be further reduced by reducing the distance between lens and lightsource until they are virtually in the same position. Still further reduction of distortions can only be obtained by increasing the distance between the lens/lightsource (as a unit) and the object.

Thus there are four variable optical factors involved in the tonal representation of an opaque object: (1) angle of incident light; (2) incident angle of image rays; (3) curvature of object surface; (4) reflection factor and texture of object surface. Most natural specimens are mixed reflectors and so it is necessary to examine separately the reactions of specular and diffuse reflectors before the reactions of any given combination of both can be ascertained.

Illumination distortions are of two kinds: highlight and shadow distortions. The latter may be either object shadow or background shadow distortion. Within the narrow range of incident angles of near-axial light there are three types of directional rays: parallel, convergent, divergent. There is no variation within the limits of parallelism of course, but convergent rays may vary within the limits of condenser diameter in relation to condenser/object distance, and condenser-diameter/object-size; while the variation possible with divergent rays is much greater, being limited mainly by practical considerations of optimum condenser-focal-length and reflector-size in relation to distribution and intensity of light, and reasonable operating conditions.

Plane Specular Reflectors under Oblique Light

Of the two types of light — oblique and axial — it is considered here that all rays of light reaching the object from a lightsource not located virtually on the optical axis of the lens are obliquely incident, and that rays emerging from an axis source but incident on an off-axis area of the object have characters in common with obliquely incident rays. Strictly speaking, only one bundle of rays satis-

*Received for publication December 28, 1953.

fies the requirements of axial light, namely that which reaches the object along the lens axis and then returns by the same path. The problem of how large this bundle may become before its outer disc of rays must be regarded as other than axially incident is analogous to the "disc of confusion" problem of lens definition, when it is necessary to determine, for a given viewing distance, at what magnitude a point ceases to be a point. The difference, then, between axial light incident upon an axial, and upon an off-axial point, is one of degree not kind.

To demonstrate the effect of an oblique light ray on a plane specular reflector, a plane first-surface mirror M-M is placed symmetrically about the optical axis of (and distant *b* from) a lens Z, as in Fig. 7. The lightsource S is positioned in the plane of the lens and distant *a* from it, so that the tangent of the angle of incidence

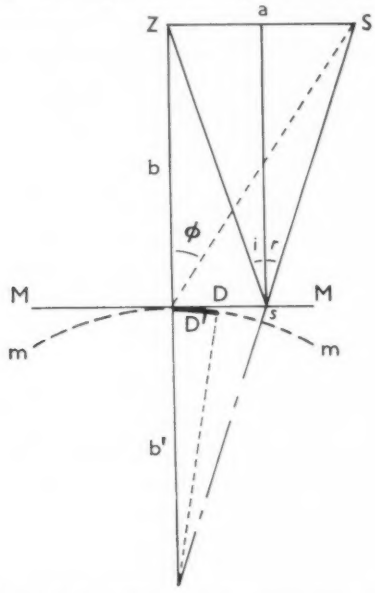


Figure 7. Distortion for a plane specular reflector (D), and convex reflector (D'), under oblique light.

ϕ at the center of M-M is a/b. The image of S is formed at *s* where the angle of incidence *i* equals the angle of reflection *r* in respect of a normal to the surface. This normal bisects *a*, so that:

$$\tan i = \tan r = \tfrac{1}{2}\, a/b = \tfrac{1}{2} \tan \phi.$$

Since $b = b'$, the displacement of the image from the center of M-M is equal to $\frac{1}{2}a$, that is:

$$D = \tfrac{1}{2} \tan \phi.$$

It is clear that to obtain $D = O$, ϕ must also equal O, when the image of the lightsource will be positioned on the optical axis.

Convex Specular Reflectors under Oblique Light

The effect of surface curvature on a reflected light ray is shown in Fig. 8 where a first-surface convex mirror m-m is symmetrically placed about the optical axis of a lens Z. The incident angle ϕ of the lightsource S is measured at the intersection of the optical axis and the mirror's center of curvature. As with a plane mirror, an image of S is formed where $i = r$ in respect of a normal that is obtained by bisecting ϕ. The arc D represents the displacement from symmetry of the image and may be expressed in radians as the product of half the incident angle and the radius of curvature R:

$$D = R \cdot \tfrac{1}{2}\, \phi_r.$$

Comparison of Figs. 7 and 8 show that for the same value of ϕ the amount of distortion is much less with convex than with plane mirrors, inasmuch as in Fig. 7 a convex mirror m-m whose radius of curvature is equal to *b* and *b'* produces a distortion of D', approximately half that of D for a plane mirror.

Perfect Diffuse Reflectors

According to Lambert's Law of Diffuse Reflection the intensity of light reflected from a perfect diffuse reflector reaches its

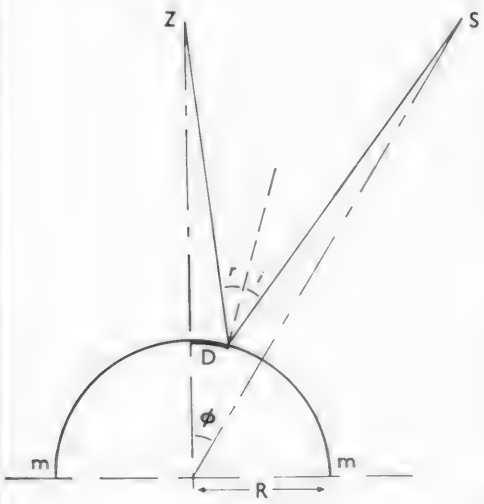


Figure 8. Distortion (D) for convex specular reflector under oblique light.

maximum in a direction normal to the reflecting surface, irrespective of the incident angle. Hence variations in the intensity of reflections from such a surface are a function of the viewing angle (θ_z) not the lighting angle (θ_s). The luminous intensity of a reflected ray I′ at an angle ϕ to the normal of the surface I may be found by:

$$I' = I \cos \phi.$$

However, as most natural specimens are not perfect diffuse reflectors the above formula is more useful in connection with materials used as backgrounds where a high degree of perfect diffuse reflection is very desirable. Owing to the presence of a specular component in natural specimens, Lambert's Law cannot usually be applied in practice and symmetry of perspective by itself is not sufficient to eliminate distortion.

Shadows as Image Components

Highlights and shadows together indicate approximately the positions of structural features. This degree of approximation is determined by the kinds and amounts of distortion present, such that any given structural feature may be said to have a *real* position, size and shape, and an *apparent* position, size and shape. The amount of distortion present determines the difference between *real* and *apparent*.

The area, shape and position of a shadow varies with perspective and illumination angles, position of object within image field, etc. An example of shadow distortion is when a background shadow falls adjacent to an object shadow, the two merge into one area of no-reflection and no object contour is registered for that area. For convenience shadows may be divided into: (1) object shadows — those produced on the surface of a specimen by projections or recessions, or the oblique angle of the incident light; (2) background shadows — cast by the object on its background. The presence in an image of either one or both of these produces distortion.

When considering shadows as image components it is important to realize that when shadows are used only to delineate areas of no-detail no detail losses can occur through overprinting, so that contrast may be forced in processing without increasing distortion. The final effect of this is to shorten the tonal range of the negative — a most desired condition considering the short tonal range of printing papers! Besides which, negatives can then be exposed for the highlights and the negative tonal range adjusted to printing paper/enlarger characteristics by adjustment of the exposure/development ratio.

Background Shadow Distortions

Equivalent ray tracings for two types of axial light, parallel and divergent, are shown in Fig. 9 (a & b). In (a) three parallel rays $S_1S_2S_3$ are vertically incident

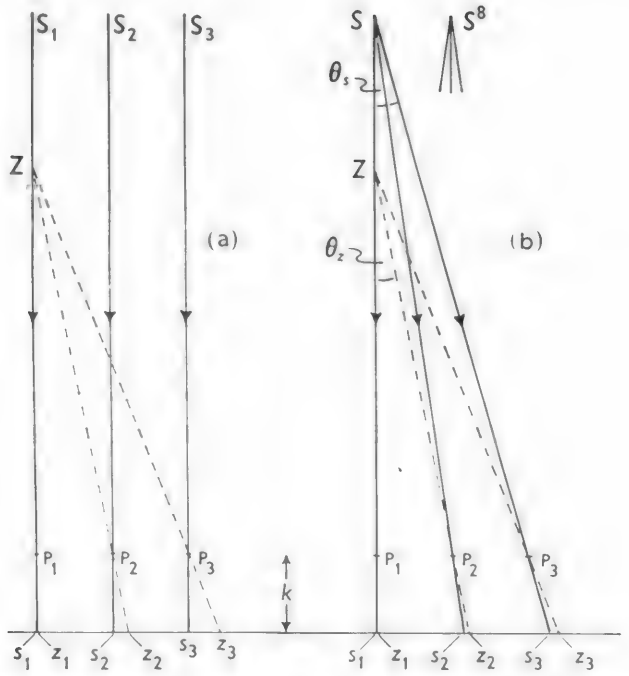


Figure 9. Background shadow displacement for parallel rays (a), and divergent rays (b).

upon three points $P_1P_2P_3$ casting three shadows $s_1s_2s_3$ on the background plane. For a lens Z, the virtual positions of the three points in respect of the background are $z_1z_2z_3$. Measured on the background plane, the distances s_1-z_1 . . . are the displacements D between the real and apparent positions of P_1 . . . in relation to their background shadows s_1 . . . : these being functions of the angle θ and the object-background distance. As this distance is constant (k) for all points,

$$D = k \tan \theta$$

In Fig. 9(b) a lightsource S is located on the optical axis and behind the lens Z, when light rays are divergent at smaller angles (θ_s) than image rays (θ_z). Again the distances separating s_1-z_1 . . . on the background plane represent the amount of displacement D, so that for divergent light rays,

$$D = k\ (\tan \theta_z - \tan \theta_s).$$

When S is virtually nearer the object than Z, D will have a negative value signifying that the real and apparent shadow positions will be reversed, i.e. shadows will be cast on the side of the object away from the optical axis. The shadow displacement effect for convergent rays (not figured) will be an exaggeration of that for parallel rays for all positions of P except P_1.

Since D is a function of k, when points P_1 . . . are located on the background plane, k = O and D = O. Also, for all values of k when P is located on the optical axis θ_z = O and D = O. Consider

the case of near-axial divergent light when S is displaced to S' (θ 8°), which brings S vertically above P_2. The incident ray for P_2 will then be parallel to the optical axis, when D = k tan O°, and P_1 (symmetrically placed for perspective) will have a shadow displaced by k tan 8°. In this case for all points to the right and left of the optical axis, i.e. between $-P_2$ and $+P_2$, D ≠ O.

Distortions Between Half-Images

The substitution of an *area* for a *point* introduces asymmetry into the image of any area about which a displaced background shadow may be visually associated with the shadow side of the area. Consider the distance P_2— P_3 in Fig. 9(a) to represent an opaque object whose shadow will fall towards the optical axis, when the P_2 edge will merge into the shadow s_2, while the P_3 edge will be distinctly outlined against illuminated background. For certain values of D it will not be possible to distinguish in the image which is object-shadow and which background-shadow, as for example when the effect is a thickening of the object outline to one side. This asymmetrical "half-image" illumination distortion is the analogue of a similar effect discussed under Perspective Distortions. Since under conditions of no-distortion the outer edge of an outline represents the *real* edge of the object, and the inner edge represents an area of no-reflection from the object surface, measurements may be made between outer edges; but when an unknown percentage of an outline thickness consists of background shadow such measurements are invalid.

To illustrate the above "half-image" distortions of asymmetrical illumination

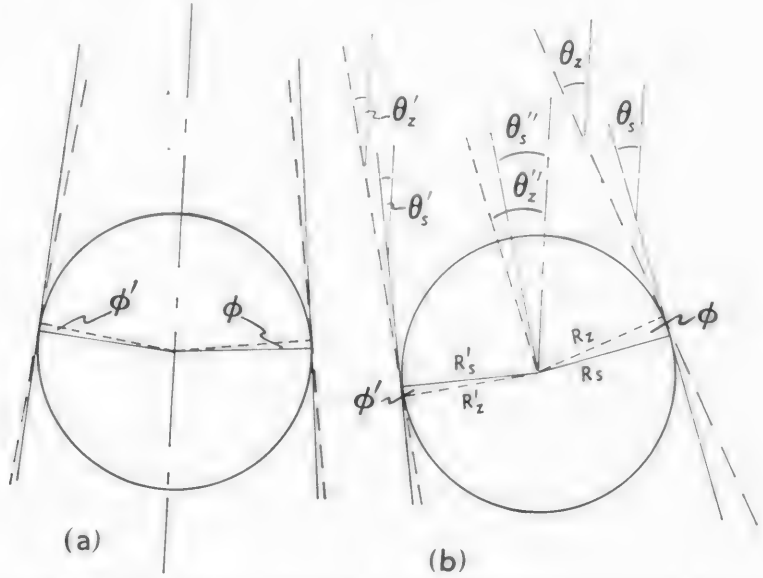


Figure 10. Distortions between half-images for (a) symmetrically placed and lit areas, (b) asymmetrically placed and lit areas.

Fig. 10 shows the profiles of two spheres, one (a) symmetrically placed and lit, the other (b) asymmetrically placed and lit. Dotted lines indicate image rays, continuous lines light rays, the relative positions for Z and S being similar to those in Fig. 9(b). In (a) since the lens is nearer than the lightsource to the object, $\theta_z > \theta_s$, which means that the object image area is smaller than the illuminated area. The points of tangency formed by the edge image and light rays to right and left respectively are separated by arcs intercepted by central angles ϕ and ϕ' where $\phi = \theta_z - \theta_s$, and $\phi' = \theta_z' - \theta_s'$. The length of each arc is the amount by which the illuminated half area exceeds the imaged half-area. As $\phi = \phi'$ there is no distortion between half-images.

In Fig. 10(b) the asymmetry of the object position gives rise to (i) asymmetrical illumination where $\phi > \phi'$, and (ii) inversion of the points of tangency for image and light rays in respect of right and left of the object. The central angles ϕ and ϕ' are unequal and therefore the arcs they intercept are also unequal; but in addition the radii (R'_s and R'_z) bounding sector ϕ' are inverted in respect of those (R_z and R_s) bounding sector ϕ. This is caused by the angular difference (of $\theta''_z - \theta''_s$) between incidence of axial image and light rays, so that for the lightsource the object is apparently rotated through an angle of $\theta''_s{}^\circ$ whereas for the lens it is rotated through an angle of $\theta''_z{}^\circ$. In relation to the axis of illumination the image axis is rotated through $R(\theta''_z - \theta''_s)$ radians, so that to obtain the sum of distortions for asymmetrical illumination and object position we must add the distortions for (i) and (ii):

$$D = R(\phi - \phi')_r + R(\theta''_z - \theta''_s)_r.$$

Distortion for a Photographed Specimen

Many of the tonal as distinct from dimensional distortions already discussed may be found in the three images of the specimen illustrated in Fig. 1. These have been re-oriented in Fig. 11 to make comparisons easier. Background shadows are clearly evident in A & C but also exist in B. In A (right) secondary diffuse reflections from the background prevent a merging of object shadow with background shadow, while in C (left) the narrower shadow is due to the contour being formed at half the distance from the background of that in A (right). Reference should be made to the three profiles (b, c and d) of Fig. 3A to compare the *real* positions of object features with the *apparent* positions in Fig. 11, the angles of light incidence being slightly less throughout than the incident angles of image rays.

Variations in the tonal rendering of edges which are areas of curvature may be noted in A, B & C (right) where A & B are similar, and C is more sharply defined. Large areas of curvature as in A & B (right) also act as secondary reflectors of background brightness, and object shadows in these areas are softened in contrast. A softness will also be noted in B (right) on examination of the enlarged image due to the edge of the background shadow fringing the object contour: this caused by the lightsource being a fraction off-axis.

Distortions caused by the specular component of convex surfaces ($D = R \cdot \frac{1}{2}\phi_r$) are present in all three pictures. Since B is symmetrical for both perspective and illumination, less distortion is present than for the other positions, there being no distortion at all for a point (--) on the X axis midway between the edges.

Figure 11. Distortions as functions of incident angles of Perspective and Illumination in a photographed specimen.

Since a point of no distortion has no meaning, with (+) as center each larger circle of a concentric series will enclose an area of increased distortion. It is suggested for this case that a circle of diameter equal to specimen width at the X axis be taken as an area of no-distortion.

For all positions of the lens (or eye) other than somewhere on the normal of a convex surface there is a difference between the *real* and *apparent* zeniths of convexity. In Fig. 10(a) a convexity is viewed from a position on the normal, when apparent and real zeniths are identical; but in (b), whilst the *real* zenith remains static, the *apparent* zenith moves through an arc subtending $\theta''_z{}^0$ at the center of curvature. However, the tonal interpretation of this shift depends on the reflection factor of the object surface, so that if diffuse the apparent zenith will always be positioned about the *apparent normal*, but if specular it will shift ac-

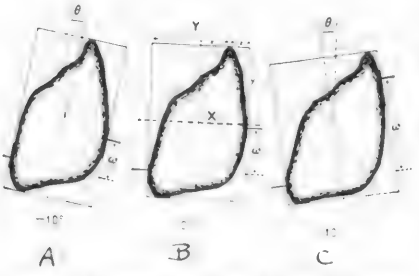


Figure 3A (taken from Figure 3, Part I.) Equivalent specimen profiles for images A, B & C in Figure 11.

cording to $R \cdot \frac{1}{2}\phi_r$. It is clear that at certain diffuse/specular ratios, when the two are in approximate equilibrium, both effects will operate equally and the apparent zenith area will be enlarged to satisfy both operations. Thus the seemingly overlarge highlight areas in some images would be the results of a fusing of two separate reflection processes.

Although no reflection factor analysis is available for the specimen photographed it is thought likely that such a dual effect is present in Fig. 11, especially in regard to the tonal rendering of the lefthand slope between the left edge and the lowest ridge where tonal depth is remarkably constant (and high) for all three images. The angles of reflection for this slope in A,B & C (measured off Fig. 3A) are:

A = 86 , B = 74 , C = 67 .

Using Lambert's Law, the luminous intensities of this surface in A,B & C expressed as percentages of those at the normal are:

A = 6.98, B = 27.56, C = 39.07.

By the same law, secondary background reflections (considering the background as a secondary lightsource) would be greatest for A and least for C, so that A would appear lighter and C darker in respect of B. Consequently these two effects are opposite and would tend to cancel one another; whereas if the specular component were greater it would act also in relation to secondary background reflections and the intensity and location of such reflections would be neither so uniform nor so evenly distributed as at present.

The apparent exaggeration of convexities may be explained in part by their relation to adjacent concavities, and in part by overall contrast increases during processing. It must be remembered that there is almost no area of surface at right angles to the normal in this specimen, and that surface features are related to a mean slope of about 32° to the normal for B. The three longitudinal highlights arise from surfaces inclined as little as 50° from the normal and therefore there is only 18° difference between max/min surface slopes.

There is, finally, the question of mental associations when interpreting tonal gradations when these alone represent structures in 3-dimension. At first glance the zenith of the ridge in A would appear to be located along the line separating highlight from shadow, because we are used to seeing objects illuminated obliquely, when a projection is bright one side and dark the other; but with axial lighting, as we have seen, the apparent zenith of a projection is, in theory, a point, and in practice an area at the normal of lens and lightsource. Therefore the real ridge zenith for A is very slightly to the right of highlight center, and for C very slightly to the left. In judging visually the extent of these distortions from the photographs and comparing them with calculated distortions in Fig. 3A, some help may be obtained by noting the positions of surface markings on the specimens.

Journal of the Biological Photographic Association Vol. 22, No. 1 February, 1954

The Use of Polarized Light in the Photography of Unstained Histological Radio Autographs of Plant Tissue*

ROBERT F. SMITH

Photographic Department, Brookhaven National Laboratory, Upton, L.I., New York.

THE use of polarized light is a simple and efficient means of observing and photographing unstained histological radio autographs of plant tissue.

In this paper we are dealing with P^{32} labelled crown-gall bacteria (*Agrobacterium tumefaciens*) in the xylem of the sunflower stem and in the intercellular spaces of the cortex of the stem of *Kalanchoe*.

It is possible to demonstrate the radio autograph and cellular detail with staining methods, but not without the loss of time, and possible damage to the specimen from chemical treatment. Phase contrast was tried but the thick dental X-ray film used for the radio autograph so reduced the contrast as to render this method useless. In bright field contrast may be increased by closing the diaphragm of the substage condenser to obtain narrow cone illumination; but by so doing there is a marked loss of resolution due to the reduction of the numerical aperture of the optical system. Another disadvantage of this method is that the silhouette effect of the cell walls obscures the radio autograph.

With polarized light the full numerical aperture of the optical system may be utilized without any of the afore-mentioned disadvantages. The accompanying photomicrographs clearly demonstrate the advantages of the polarized light system over bright field for the photography of unstained plant tissue radio autographs.

Figure A is from an overexposed radio-autograph on Kodak Dental X-ray film of P^{32} labelled crown-gall bacteria (*Agrobacterium tumefaciens*) in the xylem of the stem of sunflower. Note that even

Figure A.

* Received for publication January 19, 1954
Research carried out under the auspices of the Atomic Energy Commission

when the focus is on the tissue itself, it is impossible to distinguish cellular details of the unstained tissue.

For figure B the same data apply as for figure A, but taken under polarized light. By varying both the angles, and the degree of polarization, it is possible to show the cells of the xylem and still demonstrate the radio autograph.

Figure C is from a radio autograph (Kodak Dental X-ray film) of P^{32} labelled crown-gall bacteria in the intercellular spaces of the cortex of the stem of *Kalanchoe* under bright field. Note that the unstained tissue, with the exception of cells containing tannin, does not provide enough contrast to make details visible.

For figure D, the same data apply as in C, but using polarized light. The centers of the spots in the emulsion are now clearly demonstrated to be intercellular.

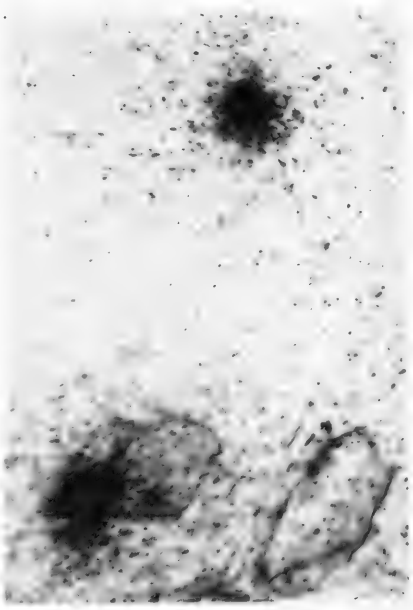


Figure C.

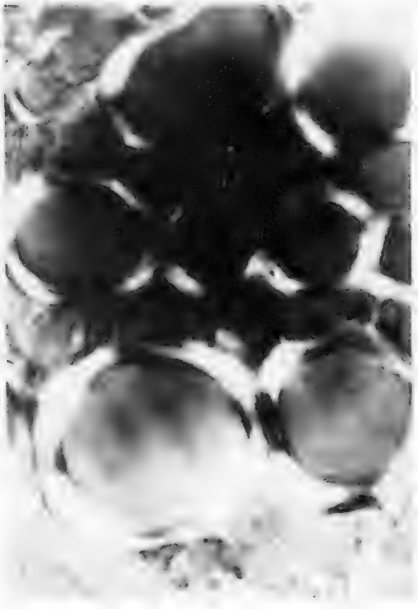


Figure B.

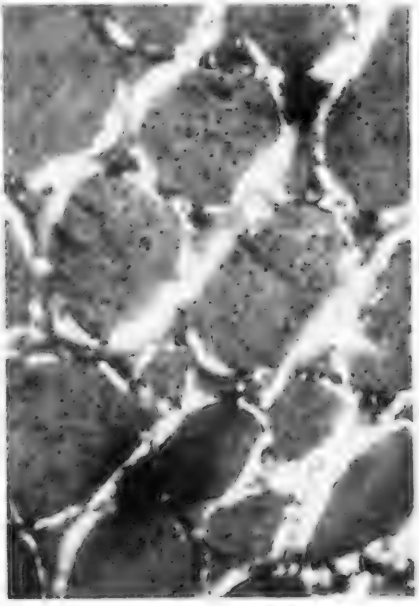


Figure D.

Journal of the Biological Photographic Association Vol. 22, No. 1 February, 1954

Using the Speedlight in Entomology*

LELAND R. BROWN

Department of Entomology, University of California, Los Angeles, California.

IN the first place, one might ask why take pictures of insects? There are several answers to this. If one is stimulated by nature photography in general, he can certainly derive considerable pleasure in attempting to make good photographs of these small six-legged animals. Because of their diversity of form, color, texture and habits, and because of the unique problems in photographing them, insect photography offers one of the most exciting fields of nature photography. And since some insects are present almost everywhere, there is never a lack of good picture material, and it is available to anyone.

But over and above the strictly pleasure or hobby phases of insect photography, there are sound economic reasons why photographs of insects are needed. Insects are man's most serious competitor in the world for food, and, conversely, man would find it difficult to produce food if it were not for certain insects. Obviously then we should know as much as possible about such an important factor affecting human welfare. A photograph, particularly in color, offers a means of communication which is both quite rapid and unique as compared to other means of communication. With a good colored photograph of an insect and the damage it does to a plant, it is very easy to explain to another person how this insect affects man's welfare, and such an explanation is more accurate and rapid than other means. The writer has found also that a good illustrated lecture is retained much better by the audience than a lecture which is not illustrated. Then, as far as the writer is concerned, colored photographs of insects are needed in education, i.e., passing information to others, in the following phases: teaching, extension work and in publication.

Insect photography can be said to be embraced in the field of low power photo micrography, that is, a range of 0.1 to 20 linear magnifications on the film. Looking at it another way, it is the field of photography which is beyond the normal close up focusing range of most cameras and up to the point where the extended camera lens is replaced by the compound microscope. For photography of living and active insects, the writer has found the 35mm single lens reflex camera and extension tubes to be a very effective instrument.

The term "photography" implies that a source of light is needed. In the past many remarkable insect photographs have been made with sunlight. But for the most part insects have been photographed in the laboratory or studio with sources of artificial illumination, that is, incandescent sources such as photoflood bulbs or conventional microscope lamps. However, incandescent sources of illumination have certain inherent disadvantages in photographing living insects. It is possible to overcome these disadvantages by the use of an artificial source of illumination

* Received for publication September 20, 1953

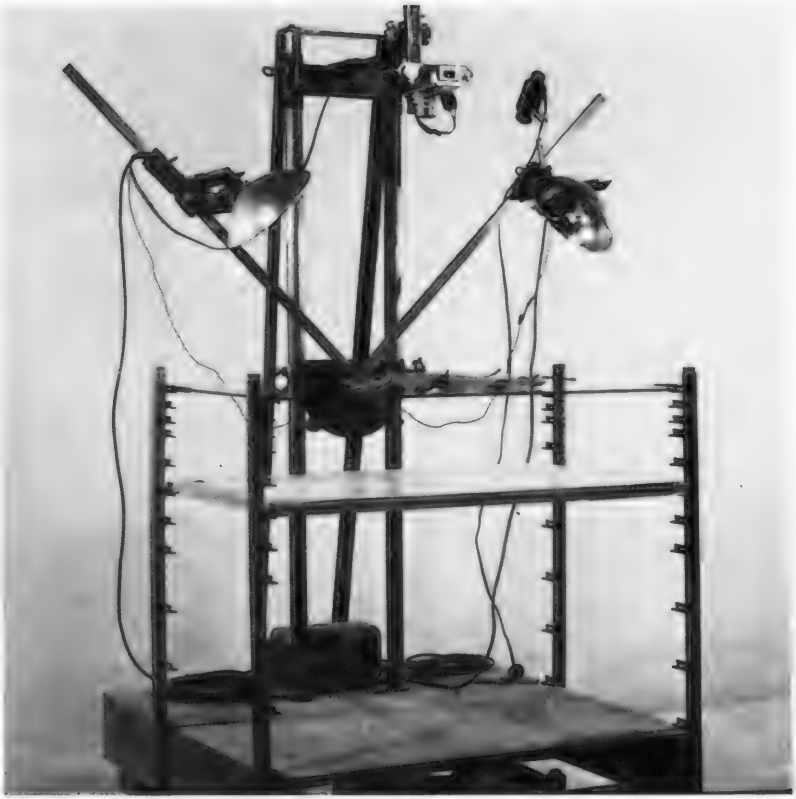


Figure 1. A standardized device for using the speedlight (2 lamps) in low power photomicrography of insects and insect-damaged plants. With this modified copy stand the position of the camera, lights (distance and angle), subject stage (of plate glass), and background stage can be controlled. A range of magnifications of 0.05X to 16.9X on the film is possible, corresponding to subject lengths of 30 inches and 2.1 mm, respectively.

made available in recent years—the speedlight (also known as electronic flash, high-speed flash and strobelight). The light produced by a speedlight unit is characterized by being a cool flash of great brilliance and very brief duration and having a color temperature somewhat comparable to average daylight.

As compared to the usual sources of artificial illumination, the advantages of the speedlight for use in living insect photography can be listed as: (a) elimination of the effects of whatever vibration may be present in the photographic set-up; (b) elimination of the effects of movement of the living specimen; (c) elimination of prolonged exposures; (d) when desirable, elimination of killing, deep anesthesia or cooling of the specimen; and (e) elimination of hot light sources.

The principal disadvantage of the speedlight is its relatively high initial cost. For low power photomicrography, however, low power speedlights, and conse-

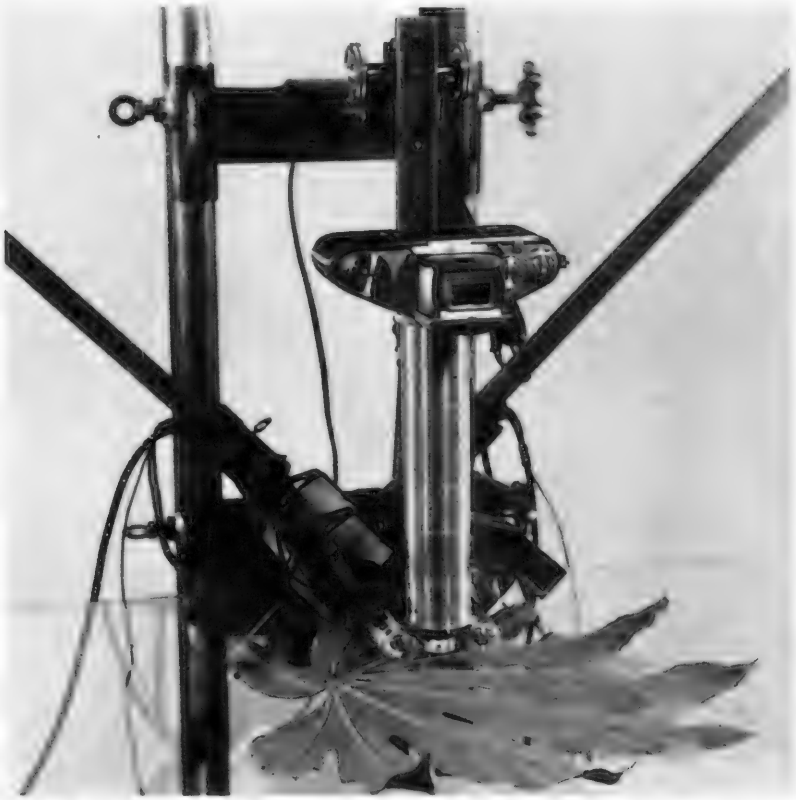


Figure 2. The standarized photographic stand set up for 16.9X magnification. Lamps are at 2.4 cm from subject; lens has a focal length of 15 mm. Exposure for this setting is 1 000 second at f 5.6 (effective f/no. 100.2). Guide number of lamps without reflectors 244 for use in centimeters and with daylight Kodachrome.

quently lower cost units, are sufficient. It should be noted also that low power speedlight units are produced currently that are less expensive than several conventional microscope illuminators.

As is well known with conventional sources of artificial illumination (incandescent or combustible sources such as photoflood or flash bulbs), the photographer has three variables he can control readily: lamp-to-subject distance, f/number, and shutter speed. However, with a speedlight the effective exposure time is so brief (1/500 to 1/20,000 of a second for most units, some special units have a longer or shorter flash duration), that shutter speed has no effect on the exposure. This leaves the photographer with only two variables he can control: lamp-to-subject distance and f/number. As far as shutter speed is concerned, it is usually set at some convenient speed and left there: with 35mm cameras with focal plane shutters 1/50 second is about the fastest shutter speed possible with speedlight.

The manufacturer usually supplies a "guide number" for various types of artificial photographic illumination, including the speedlight, of course. A guide number is a very simple but extremely useful application of the inverse square law of illumination to allow the photographer to obtain a correctly exposed film. With a given film and shutter setting, the photographer divides the guide number by the lamp-to-subject distance to obtain the correct lens aperture. Or, if a given f/number is decided upon, the guide number is divided by the f/number to obtain the correct lamp-to-subject distance. In low power photomicrography this formula should be modified to: lamp-to-subject distance in centimeters equals the guide number for centimeters divided by the effective f/number. Effective f/number equals the magnification plus one times the marked f/number.

For conventional photography it is sometimes necessary to check the guide number of the speedlight as stated by the manufacturer. In low power photomicrography the guide number should certainly be checked or determined as the speedlight may frequently be used in a manner different than as originally purchased. The guide number supplied by the manufacturer is usually supplied for use in feet. For low power photomicrography this should be changed for use in centimeters. For example, suppose the manufacturer's guide number is 35 for use with feet. Multiply 35 by 30.48 (i.e., the number of centimeters per foot) to obtain a guide number of approximately 1067. The reason for this is that, in low power photomicrography, the speedlight lamp may be as close as 2 or 3 centimeters from the subject and it is simpler to measure these distances in the metric system than in fractions of a foot or an inch.

To determine a guide number the writer has found it convenient to photograph a gray scale at various marked f/numbers and keep the following factors constant: film, magnification, shutter speed and lamp-to-gray scale distance. When the film is returned from the processor, the various exposures are projected to the original dimensions of the gray scale, and the gray scale is compared side by side with its image. Then the guide number is determined practically by inspection. For example, suppose the gray scale was photographed at 0.1 magnification with the speedlight lamps at 60cm from the center of the gray scale, and the exposure at a marked aperture of f/8 was the only one properly exposed. Then the guide number would be: $(0.1 + 1)(8)(60) = 528$.

There is a factor which must be recognized when working with certain speedlights at very close subject distances, and that is the guide number becomes less as the subject is approached by the lamp in the reflector as supplied by the manufacturer. Quite possibly this is because the reflector is not designed for work at such

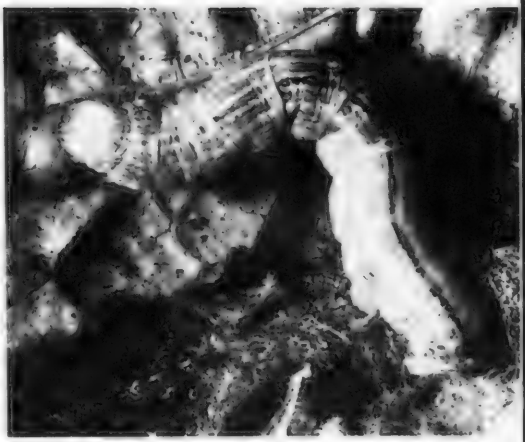


Figure 3. A living mature larva of the omnivorous looper, *Sabulodes caberata*, on an ivy leaf. Taken at 0.59X magnification on the original film using a single speedlight lamp.

close distances. If the speedlight is one in which the reflector can be detached, such as the inexpensive "Thriftlite" and certain others, then the apparent radiating source more closely approaches that of a point source of illumination, upon which the inverse square law of illumination is based. If a guide number is determined for the lamp without the reflector, that guide number can be used accurately (when measured to a point on or near the optical axis of the camera) whether the lamp is 1 inch or 50 inches from the subject. However, in order to obtain more even illumination of larger subjects, it is practical to use the reflector up to about 0.3 magnification, and from that to about 17 times, using the bare lamp.

This phenomenon of decreasing guide number, as the lamp in its regular reflector is brought nearer the subject, has been demonstrated several times by the writer with the "Thriftlite" model AC-40, and he is satisfied that it is not due to variation in film processing or other variable. The reader should not construe this to mean that the speedlight with a non-detachable reflector cannot be used for low power photomicrography. It is probable that any speedlight can be used in this type of photography, particularly at the lower magnifications. But with those speedlights having fixed reflectors, a guide number should be determined for each magnification contemplated, which amounts to the same thing as trial exposures. With a bare lamp this is not necessary. Unless one has a relatively powerful speedlight, it is not possible, at the higher magnifications, to get the lamp in its regular reflector close enough to the subject because of interference of the camera and extension tubes with the reflector.

Since by its nature the speedlight is not a continuous source of illumination, some means must be provided for light

Figure 4. A living and moving larva of the California tussock moth, *Hemerocampa vetusta*. Taken at 1.0X magnification using two speed'ight lamps.

Figure 5. A living and moving adult of the clover mite, *Bryobia praetiosa*. Taken at 5.1X magnification, single lamp.

for focusing and composing the picture. A conventional microscope illuminator can be used, and this is left on during the preliminary and taking phases of the picture. The relatively dull light of this microscope illuminator (compared to the brilliant speedlight flash) offers sufficient light for focusing and composing but only 1/10 to 1/20 the amount of light (even at its brightest) necessary for recording the image on the film. With color film this gives no practical exposure, and one need not fear ghost images appearing on the film.

Television and the Medical Illustrator*

PHILIP A. CONRATH

Associate Professor of Medical Illustration, St. Louis University School of Medicine.

WITH the ever increasing use of television as a means of demonstration in scientific meetings and as a medium of teaching in medicine, a new concept of illustration has been developed. Educational television stations are being established and an increasing number of teaching institutions are being equipped with televising facilities. Black and white telecasting is now a routine procedure (there are approximately 26 million black and white receiving sets in the United States) and color TV is an accomplished fact. We have entered an era of electronic color and color programs are being telecast daily. There are very few color receiving sets as yet but with the so-called "compatible color system" these telecasts are readily translated to black and white. Color TV has been in use on closed circuits for a number of years at medical conventions for the illustration of surgical techniques and demonstrations in various fields of medicine and medical research. The accelerated tempo with which these new concepts of audio-visual aids to medical education and research are making themselves felt, offers a challenge to the medical illustrator. He must accept it.

Generally, medical and scientific television shows may be divided into two classes namely, live or on the spot telecasts or telecasts of motion picture films, transparencies, x-rays, photographs, charts and drawings. These two classes may be and often are combined. The medical illustrator must be prepared to take an active part in the production of these shows, working in the various media, eventually including perhaps even the operating of a TV camera. It is not difficult to envision the inclusion in the future curricula of schools of medical photography and medical illustration, courses on TV camera technique.

In the presentation of the results of investigative work on a color TV program for a scientific meeting, it is usually impossible to give a live telecast. The technique in demonstrating findings is often laborious and time consuming. The duplication of findings of previous experiments in the time allotted (20 to 30 minutes) for the program is difficult to predict. Many investigators record their findings on color motion picture film. With editing, a very informative film can be created. Sometimes but more often not, these films are made with color television in mind. The color television system can transmit a color motion picture film only to the degree of excellence to which the film was made originally from the color viewpoint. Each film presents its own problem but generally there are several factors to be considered in making color films which may be used on color television. Flat lighting should be used with accessory lights to fill in shaded areas. Large shaded areas do not televise well. Close-ups are far more satisfactory than

* Received for publication February 23, 1954.

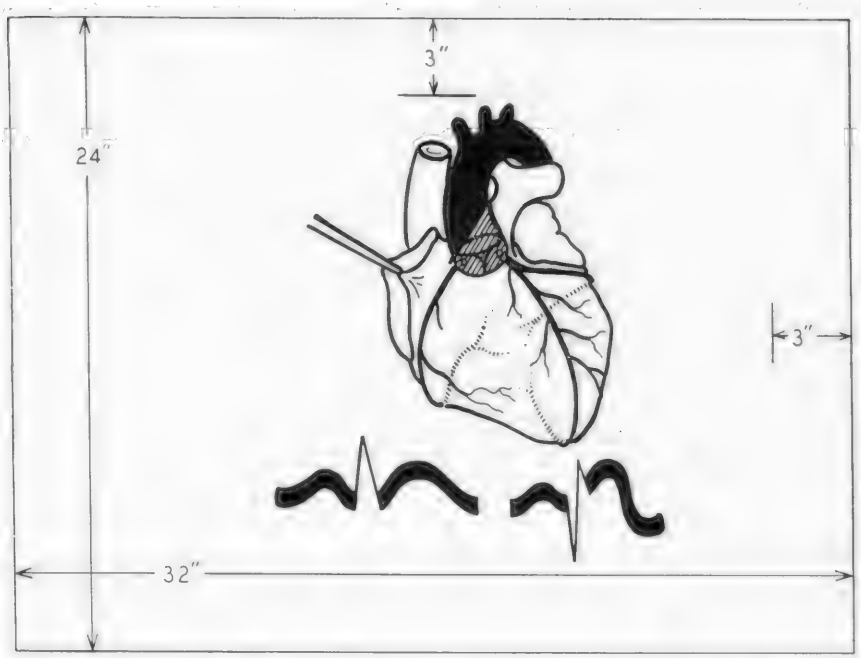


Figure 1. Dimensions of card board and maximum area available for the illustration. Proportions of the object illustrated sometimes preclude use of all the area.

long shots, particularly where color and detail are important. If the picture is one of a surgical operation the drapes and instruments are important accessories in a good color picture. White drapes are not desirable because they reflect the television lights, can distort color and are hard on the eyes. Light green drapes give a much better color sensation and are restful to the eyes. If at all possible dull finish instruments should be used. Highly polished chrome instruments are apt to flash intense gleams of light which are very distracting. Should color television be unavailable, a good black and white telecast can still be made from the color film by the "compatible system" which is now in use. The electronic system translates the colors to their proper shades in the black-gray-white tone scale just as the eye does.

Color transparencies which are project ed on a screen and photographed with the TV camera must also be very carefully made. The densities must be such that when they are projected on the screen, they have good color quality and are neither too light nor too dark. If the photographer has control of the color arrangement he should use complimentary colors in achieving color harmony and color separation between foreground and background objects.

Color prints may also be used as illustrations. Since they are opaque, they reflect rather than transmit light. Therefore their densities are important. Color prints should have a low maximum density so that the colors will televise well. Dimen-

Figure 2. Photograph of a drawing made for color TV on pale green card board, 32" x 24". The drawing is done in light tones of red, yellow, green and blue in a very sketchy technique.

sional proportions should be 3 vertical to 4 horizontal.

X-rays present a problem in that they run counter wise to the dimensional proportions of the television screen. They are in the vertical axis and this affects the size but which cannot be avoided. To show well x-rays should have good contrast. Densities in the shadow area must be of a quality that when televised, will show diagnostic detail.

At a recent A. M. A. interim meeting the institution with which I am associated was asked to put on a series of shows for color TV. They were to be telecast from a local hospital and were to consist of surgical operations with charts and drawings to emphasize important points of anatomy, operative technique and pathology. The medical illustration department was intrusted with the task of preparing the charts and drawings. The telecasts were to be screened in the various meeting rooms in the municipal auditorium. The distance from the screen to the rear of the room was between 40 and 50 feet. The screen size was about 6 feet square. Charts and drawings to qualify must be legible from the maximum distance. Time being of the essence, there must be a minimum of lettering on the charts and the drawings must be in a technique that car-

ries the image well and quickly to the audience. The size of the board on which they are made is 24 inches by 32 inches in the horizontal axis. Since the light from the television scintillates, a dull surface paper must be used. A shiny surface will reflect the television lights and degrade the image.

Lettering on the charts should be simple, not too crowded and not too open face. Letters should be about 2 inches high and from 3/16 of an inch to ¼ of an inch in width. A dull finish black or red pigment may be used on a white board but light red lettering on a pale green board is preferable. If the chart is telecast in black and white a more pleasing restful image will result than the harsh image from a black and white chart. Red lettering on a pale green background will be translated to a dark gray on a light gray background. It has been found that red, which photographs black, on television will be dark gray. Blue, which photographs faintly if at all appears as a pale gray on television. Green photographs as a dark gray but on television is light gray. Chrome yellow which photographs almost black is a medium gray. Modifications may be made by adding white to the pigments.

In illustrating points on anatomy and on surgical technique, simple line drawings may be done in black with red and blue to accent the blood vessels. Drawings are made on a board 24 inches by 32 inches with a free border of about 3 inches all around. Show card color or casein color are used so brushes and not pens to make the bold wide lines are used.

To demonstrate pathological conditions with drawings, color is more effective than black and white. Working on a pale green board of the same size as that above, the drawing is planned to fill most of the surface, leaving the same border all around. The usual wash technique is not used. Instead, a very bold, free and sketchy combination of a line and wash technique should be used. The atmosphere intervening between the screen and the audience will help to soften and blend the tones. At the same time the spontaneity and freshness will be preserved. Casein color is the medium of choice because of its versatility and adaptability to the technique. The palette should tend toward the pastel tones. Strong colors may photograph too dark, particularly red and green. The illustrator has the advantage that his work will be subject to close-up shots. This will insure better color reproduction and sharpness.

From the foregoing it can be seen that perfect cooperation between the producer, the doctor and the medical illustrator is essential. Each must understand what the other is trying to do. Only in this way is it possible to put on a show that has technical excellence, scientific value and visual appeal.

The information furnished by Mr. Keith Gunther, Director of Television Production, KSD-TV, St. Louis Post-Dispatch, is gratefully acknowledged.

The Stanford Research Institute Aerosol Camera*

E. J. WIGGINS, E. ROBINSON, and D. H. HUTCHISON

Introduction

AN aerosol is usually defined as a suspension of solid particles or liquid droplets in air. It has been facetiously remarked that someone or other will consider everything from large molecules to small birds as aerosol particles. However, we shall confine our attention to particles of the size range of greatest general interest, roughly 1 to 100 microns in diameter.

Aerosols are important in everyday life. Among natural phenomena, clouds, fogs and all forms of precipitation are either aerosols or involve aerosols as an intermediate stage. Industrial processes involve aerosols in many ways, both as useful materials and as unwelcome by-products such as dust and smoke. Many branches of agriculture could scarcely operate on their present scale without the use of insecticide aerosols generated on the ground or sprayed from airplanes. The armed forces may use aerosols defensively as in smoke screens, or offensively in chemical or bacteriological warfare. The physician applies medication in aerosol form so that it may reach and be retained on otherwise inaccessible surfaces. Even the householder makes his acquaintance with aerosols in the form of "bug bombs" and self-spraying paint cans.

A knowledge of aerosol properties is also of interest to almost all branches of pure and applied science. The meteorologist wishes to know such things as the size distribution and concentration of water droplets in a cloud, the dynamics of their growth and disappearance, and the properties of the nuclei (themselves aerosols) which led to their formation. The pharmacologist wishes to know the size distribution of the constituent particles so that he may estimate the proportion that will be inhaled and retained, and in some cases also the surface area or structure insofar as they affect the speed of action. The entomologist wishes to know the size distribution to predict rate of fall, wind travel, and ability to penetrate foliage, and also the composition of the particles as they reach the target since they may have suffered loss of active material by evaporation or by decomposition in the dispersal device. The air pollution investigator must know not only the medical composition of the particles to identify their source, but must also consider the possibility of chemical reactions in or between particles after their initial formation.

A great variety of methods has been devised for studying the composition and properties of aerosols. Most of these has had one factor in common. The con-

* The research reported here was sponsored by the Geophysics Research Directorate of the Air Force Cambridge Research Center, Air Research and Development Command, under Contract No. AF 19(122)-634. Presented at the 23rd Annual Meeting, Los Angeles, 1953

* Received for publication September 30, 1953

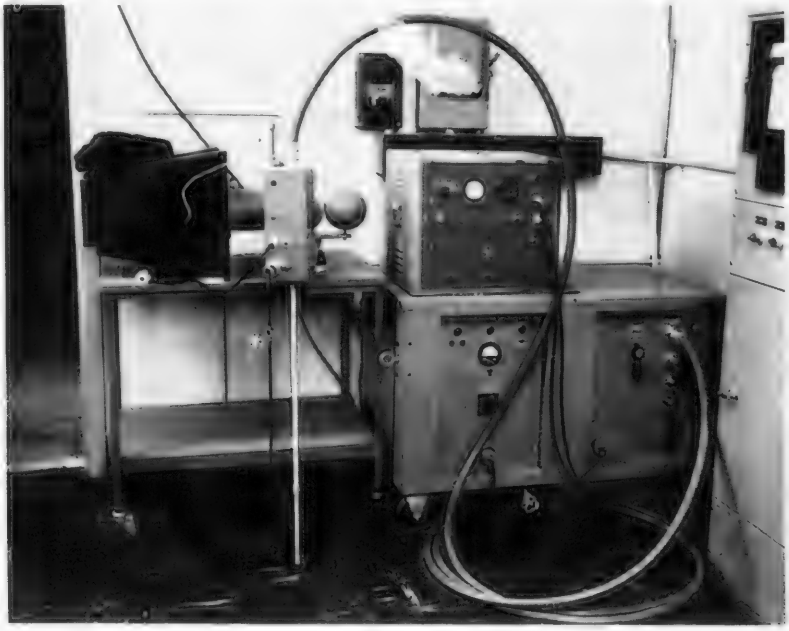


Figure 1. The Stanford Research Institute Aerosol Camera.

stituent particles have first been collected on a solid surface and then examined in a stationary position by standard microscope techniques. The collection may be made by simple settling, by impingement from an air jet, by thermal or electrostatic precipitation, or by all sorts of variations or combinations of these methods. The actual collection surface may be a bare slide or may be coated with a viscous or plastic film, or with a matrix of small solid particles. In any case, all such methods have the common factor of concentrating a sizable sample of the aerosol particles into a definite area, and immobilizing them for subsequent examination.

Before deprecating this procedure, it should be conceded that this technique is entirely satisfactory for many purposes, and indeed much of our present knowledge of aerosols was obtained by this means. However, there are several admitted shortcomings to such collection techniques. Almost all such methods of collection tend to bias the size distribution of the particles by preferentially retaining or rejecting certain sizes. Methods other than gravity settling apply mechanical stresses to the particles which may shatter or deform delicate materials. Agglomerates may be broken up or new ones formed. Supercooled liquid droplets may solidify on contact with the collection surface, even when viscous coatings are used. Finally, the period which must elapse between the start of collection and final microscopic examination or photography may allow loss of volatile components or chemical reaction.

The problem of determining the true concentration and size distribution of the particles in the original aerosol can be

met to some extent by optical techniques in which the number and intensity of scintillations are recorded photoelectrically with dark field illumination of the aerosol stream. In favorable cases similar information can be obtained by measuring the electrostatic charge carried to a collecting electrode or the cooling of a heated filament on impact of each particle. However, such methods involve empirical calibrations for each material, and give no direct information about particle shape or structure.

It is obvious that the most desirable procedure would be to take an actual photomicrograph of a sample of aerosol with the particles in suspension in their undisturbed state. The difficulties are almost equally obvious. The constituent particles of an aerosol are in continual motion due to air currents, convective turbulence, gravity settling, and Brownian motion. At reasonably high magnifications, the exposure necessary to obtain a sharp photograph is very short. Since the particles are also very small, the light intensity necessary to obtain an image on a photographic film is exceedingly high. The majority of aerosols are relatively dilute, necessitating a large volume of field to obtain a representative number of particles in focus.

The first approach to a solution was the shadow camera, in which axial illumination is furnished by a high-intensity flash lamp behind the aerosol sample. The aerosol particles thus show up as silhouettes against an exposed background. Particles within the depth of focus of the camera lens can be distinguished by their sharper images, and can be counted and measured as desired. This device has proven useful for many purposes, particularly in connection with liquid sprays where droplet size only is of interest and concentrations are high. However, it gives little information on particle shape or structure and allows only one exposure per film. With dilute aerosols, many photographs may be necessary to obtain sufficient information on size distribution.

The next step is the use of side lighting to obtain actual photographs of the particles. Dark field illumination enables a number of exposures to be made on the same film to increase the probability of finding sufficient particles in the photograph. If the illuminated zone is made to coincide approximately with the depth of focus of the camera lens, out-of-focus images are eliminated and background light is further reduced.

These improvements cannot be made without paying a considerable price. The camera lens system must have a large depth of focus to obtain a volume of field great enough to enclose particles with reasonable frequency in a dilute aerosol. This depth of focus may be as much as one hundred times that required with a microscope slide. The working distance from camera lens to field must be large enough to avoid disturbance of the aerosol by the solid surface. A distance approaching two inches is considered necessary for some purposes, compared to a small fraction of an inch in a standard microscope. At the same time, resolution and magnification must be sufficient to meet the intended function of the instrument, and the light-gathering efficiency should be as high as possible. Unfortunately, the laws of optics dictate that all of those desirable characteristics cannot be obtained simultaneously.

In the literature which was available to us at the time this development was started, the closest approaches to our requirements were cameras designed for photography of cloud droplets from air-

craft in flight. These used the principles of darkfield illumination with a pulsed light source, but the available light intensity and other factors limited the usable magnification. The resolution was therefore limited not only by the optical system but also by the grain size of the film when it was enlarged sufficiently for measurement of small particles. In our own work it has been found possible, by using a sufficiently intense light source, to reach compromises between magnification, resolving power, and depth of field which are satisfactory for many applications. The optical system in use in the prototype SRI aerosol camera yields a resolution of approximately 2 microns with a depth of field of 200 microns. The objective lens is a 50-mm f/4.5 Micro-Raptar, used in conjunction with a standard 6, 10, or 20 times microscope eyepiece. A resulting magnification of 24, 40, or 80 times is produced on 5 x 7 inch photographic film. The photographic image can be subsequently enlarged in favorable cases to provide overall magnifications up to 400 times. Another combination where higher resolving power is required but where a shallower depth of field may have to be tolerated, is a 1-inch f/1.9 Ciné-Raptar and the same eyepiece lenses. This produces a resolution of better than 1 micron.

The light source has so far proven to be one of the more difficult problems, due both to the low efficiency of the camera optics and the required characteristics of the illumination system. The present light source is capable of producing flashes lasting 1 to 8 microseconds at repetition rates up to 100 per second. The actual flash lamp is a straight-tube General Electric type FT-127, operated at voltages up to 25 kilovolts. The high voltage pulses are obtained from a radar modulator type of circuit using a hydrogen thyratron. The entire light source is similar to those designed for ballistics photography, although capable of somewhat higher energy per flash than those normally used. Modifications are currently being made to increase the energy still further by lengthening the duration of the light pulse, since it has been found that the exposures originally selected were shorter than necessary. The light source and associated equipment represents a considerable part of the entire cost and most of the bulk and weight of the complete aerosol camera. The present unit weighs over 500 pounds and consumes up to 3 kilowatts of power.

The flash tube is mounted in a forced air cooled enclosure in the camera assembly for safety and mechanical protection. An image of the arc discharge is focused on an adjustable slit by a pair of short focal length condensers. A reduced image of the slit is, in turn, projected across the field of the camera. The width of this image is adjusted to approximate the depth of focus of the camera, and the illumination system is mounted on an arm pivoted at the center of the camera field to allow adjustment for optimum angle of illumination. This type of construction also allows the flash lamp to be removed as far as possible from the field of view to minimize disturbance of the aerosol by heat from the lamp.

The aerosol camera and its components are shown in the photograph. The power supply is contained in the large unit in the lower right, while the smaller unit on the right contains the control circuits. The lamp house is in the center and is connected to the power supply with a length of heavy coaxial cable. The actual camera is shown on the left.

The development of this camera is still very much in progress, and we do not expect to reach the limit of useful im-

provements for some time to come. Even in its present form the applications for such a device seem to be very extensive. One immediate problem which stimulated the development of the camera is the controversy over the nature of the constituent particles of arctic ice fogs. These may be ice particles or supercooled water droplets, which are completely indistinguishable by normal collection methods since immediate freezing occurs on contact. The aerosol camera should make possible the certain identification of the original nature of the particles in this and many similar cases.

An even more interesting possibility is the use of repetitive exposures to follow the actual history of an unstable aerosol particle over a short period. Some problems in which such "micro movies" would be invaluable would be the breakup and evaporation of liquid droplets in an air stream, agglomeration in sonic fields, chemical reactions between aerosol particles, and the like.

Finally, there is no fundamental reason why the technique should be permanently restricted to aerosols. It should be quite possible to photograph particles in liquid suspensions, provided the concentration of colloidal or high molecular weight material is not so high as to produce excessive scattering.

Acknowledgments

Taking part in the present development program were William C. Thuman, Gordon B. Bell, and Dr. Richard D. Cadle. They contributed a great deal to the several phases of the research.

MEDICAL AND BIOLOGICAL ILLUSTRATION

Volume IV — No. 1 January 1954

CONTENTS

Isotype Charts, Marie L. Neurath

Antonio Scarpa, W. J. Bishop

Line Block Reproduction of Radiographs, Sylvia Treadgold

35mm Reversal Material in Medical Photography, C. E. Engel

A Photoelectric Exposure Meter for Photomicrography, A. C. Johnstone and E. V. Willmott

Superimposed Titling Methods, Dugald R. McDougall

A Wax Moulage Technique, Felix and Alvin Shemesh

Equipment and Methods:

A Simple Light-Pointer
Metrolux Clinical Photographic Unit
Rubber Electrical Accessories
The Techne Universal Microscope
Scaling of Illustrations
Time Interval Meter

Abstracts

Book Reviews

Motion Pictures

Reports from Societies

Annual Subscription (U.S.A.) $7.00

Published by the British Medical Association, London, England
Send orders to Grune and Stratton, Inc., 381 Fourth Ave., New York 16, N.Y.

Planning the Radiograph Copy Negative*

WILLIAM E. PERRY
Chief, Medical Illustration Laboratory Veterans Administration Center, Dayton, Ohio

Introduction

THE radiograph, itself a photographic image, has long been established as an important diagnostic device, thus it is little wonder that the practice of copying radiographs has come to be so wide-spread. Frequently, the only existing pictorial evidence is the radiograph: and its reproduction, for purposes of publication or otherwise, assumes paramount importance. At the very least, it is more convenient for a large group to see a projected image of the radiograph than it is for them to crowd about a view-box in order to see the original.

Copying the radiograph is then important: but just as important is that the reproduction be a good one. Copying radiographs can, at times, pose a problem: and as the solution to any problem lies in a full understanding of the problem itself, it is necessary to study not only the properties of the negative material in use, but also the properties of the subject (the radiograph) and the printing material as well. The copy negative can only serve as a means of liaison between the radiograph and the printing material, therefore it is important that the properties of the latter two be well understood before an attempt is made to plan the copy negative.

Properties of Printing Materials

In general, the variable properties of printing papers are speed, contrast, surface, image tone, color of paper stock, and weight of paper. It can be assumed that the paper of choice will have a glossy surface on a white paper stock. The speed will be determined by the type of printing equipment in use, either contact or enlarging, and the image tone and weight of the paper are of no consequence save for personal preference. Of these properties, then, only one need be considered, — the contrast, or more specifically, the paper's ability to reproduce given density ranges of the negative. In this sense, lantern slides are commonly handled on a basis comparable to that of a given contrast-grade paper. As such, it will be necessary to consider only those contrast properties associated with printing papers.

* Received for publication August 15, 1953

Printing Paper Contrast

It may be well to point out that contrast in a paper is quite a different matter than it is in a negative. It is NOT a measure of the range of densities from black to white. Rather, it is a measure of the exposure required to cause a just perceptible tone to appear as compared to the exposure required to produce black. All contrast grades for a given type and surface of paper will have the same density range; i.e., the white of the paper itself to the maximum black that the paper is capable of producing. Characteristic curves have been plotted by the manufacturers for the many papers and are valuable aids in "seeing" how the various contrast grades of these papers differ. The properties of Eastman Kodak Kodabromide Surface F (glossy) paper** will serve for further analysis. This paper is supplied in five contrast grades, 1 through 5. The log exposure scales for the various contrast grades are given as follows: #1 — 1.45; #2 — 1.15; #3 — 0.9; #4 — 0.6; and #5 — 0.5. These exposure scales are expressions of the range of light intensities required to produce a print having the full range of useful tones from black to white. The reflection density range is the same for all five grades of paper, from 0.00, the white of the paper itself, to approximately 1.7, maximum black.

The Radiograph

In general, it may be said that the most significant property of the radiograph is the density range. Many factors influence density range at the time the radiograph is being produced: applied kilovoltage; elimination of scatter radiation; characteristics of the film emulsion in use; characteristics of the intensifying screens; developer; agitation; and development time. In addition, contrast is dependent upon the absorption coefficients of the various substances which lie in the path of the X-rays. An example of some of the common absorption coefficients are: subcutaneous fat — 0.76; muscle (biceps) — 1.30; bone — 5.60. (Based on an applied kilovoltage of 60 kv.) In light of the foregoing, it can be seen that the density range can vary considerably.

** As Eastman Kodak products are the standard in this laboratory, only these products were considered.

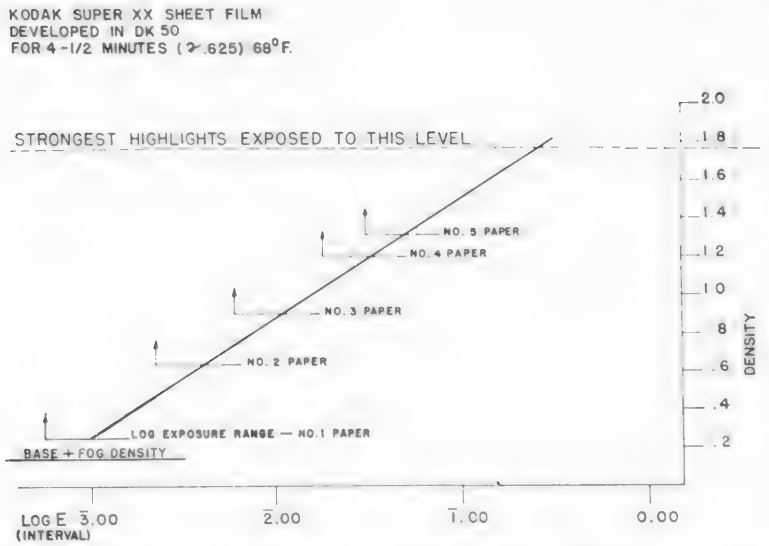


Figure 1. Characteristic curve of Eastman Kodak Super-XX sheet film developed for 4½ minutes in DK-50. The contrast producing properties are shown schematically, e.g., the short range of negative densities included in the range of the #5 paper could exist at either end of the curve.

A study was made of a series of radiographs and it was found that the maximum density exhibited by any radiograph was 2.6. This reading is based on the maximum density to be found within the "field." The practically opaque periphery found on most radiographs was disregarded inasmuch as it is due to the unimpeded flow of X-rays and has no significance with regard to interpreting the radiograph. The minimum density can be taken to be 0.17, the base plus fog density. The maximum density range for any one radiograph was found to be 2.4 It can be seen from the foregoing that the maximum density range for any one radiograph is approximately consistent with the maximum density range exhibited by all radiographs in the series. (Maximum density—2.6, minimum density—0.17.)

The Copy Negative

Thus far, the problem of producing the copy negative is resolved about the following: Radiographs have a maximum density range of 2.4 (approximately), both singly or as a group. This implies that the copy negative must be able to record tones over a log exposure range of 2.4. In turn, as the copy negative must be printed on paper having a log exposure scale no greater than 1.45 (Contrast grade #1), the density range of the copy negative must remain within a density range of 1.45. Also, all points of the pertinent exposure should lie on the straight line portion of the characteristic curve to avoid blocking of tones, which will occur if part of the exposure should lie on either the toe or shoulder portions.

The curve which will be consistent with the foregoing criteria may now be visualized.

In order to place the point at which the minimum shadow density should occur, it is necessary to take into consideration the average base plus fog density which will be encountered with the negative material. This can be taken to be on the order of 0.15. In consideration of this value, it was felt that the minimum shadow density should occur at a point not lower than 0.3 so that the darkest shadow portion will present good tonal separation from that of the unexposed areas of the negative. The highlight point was then placed so that the resultant curve would extend over a range consistent with the maximum log exposure scale available paper-wise (1.45).

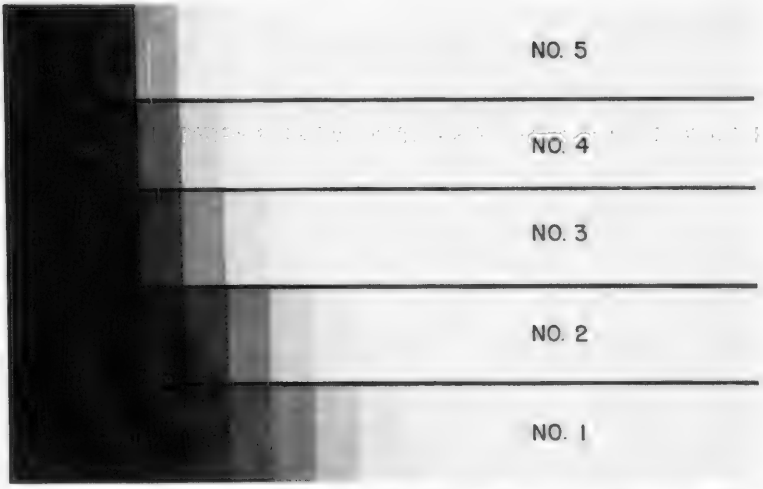


Figure 2. Exposure scale relationships of the various contrast grade papers. The negative used in printing these samples had density steps which were successively greater by 0.15 (approximately).

In selecting the negative material, the only property which assumed importance was that the negative material must be capable of producing a characteristic curve with a long straight line portion: that is to say, the negative material must not exhibit a tendency to shoulder readily. As Eastman Kodak Super-XX possessed this property to a marked degree, its choice was apparent.

An empirical approach was used to produce a copy negative having the desired characteristic curve. It was first essential to determine approximately the exposure necessary to place the deepest shadow (radiograph density 2.7) at 0.3. This was done by making a series of exposures of increasing exposure times and then arbitrarily developing these various tests to gamma 0.7. It was then necessary to determine the approximate time of development necessary to place the highlight point (radiograph density 1.7) at 1.75. Lastly, a final adjustment was made in both exposure and processing times to bring the shadow point and the highlight point to their proper levels (Figure 1) and to insure that all intermediate tones lay on a straight line between these two points.

Summary

As the radiograph copy negative has been planned to record the *maximum* density range of any radiograph within the limits of a No. 1 contrast-grade paper, all radiograph copy negatives are exposed and processed exactly alike. The final exposure and development determinations were: The exposure for the given conditions was consistent with a Weston speed of 6 (meter held in contact with the opal glass). This can be considered only a tentative value. Light sources vary considerably in their spectral output, and this and other factors must be taken into consideration when establishing the effective film speed for the reader's own use. The film was developed in DK-50 for 4½ minutes at 68° F. Radiographs having density ranges less than the maximum can be printed quite readily on one of the higher-contrast-grade papers (Figure 1). Though the density ranges possessed by these lower-contrast radiographs are less than the maximum to which the negative has been planned, all portions of the pertinent exposure will lie somewhere between the shadow and highlight points on the characteristic curve. As the gradient slope of the characteristic curve is 0.625, adequate tone separation will be realized.

In conclusion, a word of caution may not be amiss. Though these pages speak of a standardized method it is hoped that the reader will not interpret this to mean that radiographs may be copied "any old way." There is no substitute for careful technique.

Hospital and Medical Photography*

PHILIP D. BONNET, M.D.
Administrator, Massachusetts Memorial Hospitals, Boston, Massachusetts

MEDICAL photography is one of the 28 different technical specialties now associated with the practice of medicine and the protection of the health of the people. Except for the unchallenged role of the physician at the top of the hierarchy, the relations among the other specialties has not become stabilized. However, it may encourage you to know that in a recent recruitment bulletin, Medical Illustrators and Medical Photographers are listed in the middle between X-ray, Laboratory Technicians, and Dental Hygienists. Whereas Hospital Administrators come near the end, sandwiched in between Meat and Garbage Inspectors and Medical Secretaries. In a way this is poetic justice, but in a way it is also an illuminating incident because it is doubtful that any stable relationship is possible among all these specialties. There can be no hierarchy. Each specialty has its vital function to perform in order to create an effective whole. We must all try to keep our eyes on the main objective, namely, health, even while we are each of us trying to perfect our special skills and tools for the immediate work in hand. The challenge before us all is to promote health, prevent disability, and cure disease. None of us can do these things alone. It is only the health team which can do them. The health team is now a bewildering complex of know-how, skill, and wisdom

As a hospital administrator it is my good fortune to have a vantage point from which to see some of the vistas and the panoramas, and to observe some of the forces which are bringing about changes. To summarize very briefly, the important trends in health care as I see them are these:

1. Growing teamwork.
2. Relative despecialization of physicians
3. Reorientation of medical education
4. Increasingly effective prevention of disability through health education and social progress
5. Development of comprehensive programs of health service with emphasis on prevention and continuity
6. Greater integration geographically and functionally of all of the health specialties.

We seem to have all of the technology and the know-how at the moment that we can put to effective use. The most important question is whether we can grow in wisdom — both spiritual wisdom and practical wisdom — so that we can again recognize right and wrong and tell good from evil. The weakness of all technology is that it places a premium on standardization, uniformity, and conformity dehumanization. We must find the spiritual resources to resist wisely certain aspects of technology, to recognize the importance of differences, the importance of each unique individual. Technology is only a tool, impartial and impersonal. The only thing which determines how well it is used for good or bad is the human mind and spirit.

After this somewhat long digression let us return to the hospital itself and medical photography. Let us try to define the place of medical photography. It is usually stated that the three main functions of a hospital are:

1. Care of patients
2. Medical education
3. Research

Actually these are all subdivisions of one function: the care of patients. The only difference between education and research on one hand and the present care of patients on the other is in the time factor. Neither education nor research are ultimate ends in themselves. They are directed towards the care of future patients. In biological terms education represents reproduction and proliferation, and research represents differentiation and maturation of the health care organism. It is quite clear, however, almost self-evident, that progress is dependent entirely on education and research or concern for the future. Incidentally, taking a future for granted nowadays is something that all atheists should ponder.

It is this concern for the future that creates the setting for Medical Photography. Without this basic condition it is very doubtful that hospitals would emulate the pack rat and create a museum of useless medical pictures and other oddments. The photographic archives of most

* Presented at the Annual Meeting, September 2, 1953, Los Angeles, California
Received for publication October 7, 1953

hospitals offer little inducement to enlarge them.

There is, of course, a place for photographic records of historical events and unusual cases or specimens, but it is a small place, and it is not a justification for a department of photography in a hospital. The justification is in the making of photographic records for a purpose. It may be a general purpose or a specific purpose, but is the making of records for a purpose.

Now, why locate a medical photography unit in a hospital? Why not in a doctor's office building or in a photographic salon? The answer is so obvious that it is overlooked, and is the reason for the growth of hospitals. It is located in a hospital because that is where patients (or, in other words, specimens) are, the patients are there because the doctors are there, and the doctors are there because the tools are there, and the tools are there because they have become so big and heavy and costly that they cannot be carried around by the doctors. This too is why doctors, nurses, and technicians must receive a major part of their education and training within the walls of the hospitals.

Any hospital actively engaged in medical education and research must sooner or later recognize the need and provide for a medical photography unit since one of the most valuable tools of medical education is the "visual aid" - - drawings, photographs, slides, movies, and perhaps T.V

You have no doubt all heard the report that we learn or retain only 30% of what we hear, only 50% of what we see, and 70% of what we actually do It is this superiority of visual learning over the auditory learning of the old didactic lecture system which has led to the present advanced development of medical photography. Being an iconoclast, 50% sounds to me only fair as a method, and if the present emphasis on visual aids is to continue, that percentage must somehow be raised by improved techniques or improved students. It would, I presume, be heresy to be somewhat skeptical, if not scared, of the thought of attempting to combine seeing and doing in the medical field through 3D or Cinerama.

At the Massachusetts Memorial Hospitals, which is the principal teaching hospital affiliated with Boston University School of Medicine (which is one of the finest there is), this need for medical photography was recognized later rather than sooner and was established in 1947. Prior to that time there was a little amateur stuff, but what little work there was was farmed out — to everyone's complete dissatisfaction.

In recognition of the importance of medical photography for teaching, the alumni of the School of Medicine made a grant to purchase the initial equipment and get started. The department attempted to combine medical art and medical photography under the rather vague label of Medical Illustration. No criticism of individuals is implied or intended. With a staff of two, proficiency in both fields was impossible, and after a four-year trial of that uncompanionate marriage, an amicable divorce was arranged. We now have a Medical Photography Laboratory, in able charge of which is your member, Miss Marian Dawes, and a Medical Art Laboratory. It is of course obvious that there must be a close working relationship between Medical Photography and Medical Art since they often utilize the same specimens and in many ways supplement each other's work.

Architecturally, our Photography Laboratory is far from ideal. It was not designed for the purpose and is vest pocket in size. But wonder of wonders, it is not in the basement or behind the boilers, it is squarely in the middle of the Research laboratories, an advantage which outweighs many disadvantages. I am not competent to detail the intricacies of lenses, papers, exposures, lights, developers and any technical questions must be asked of Miss Dawes.

Having a department of medical photography, my problem as Administrator becomes how to bring it into proper relation with other departments. A hospital is very complex There are always more demands and needs than can be handled at any one time, and it becomes necessary to decide what receives priority, which department needs new equipment most, where maintenance effort must be allocated first, when more support is so necessary for one department that the budget for another department must therefore be reduced In other words, how to keep the parts of the whole organization in such a reasonable state of harmonious balance that the whole is greater than the sum of its parts, not just equal to the sum of its parts but actually greater than it.

Each department exists for the sole purpose of rendering service — service to patients, service to doctors, service to departments, service to the public. It does not truly exist for the benefit of the hospital since the hospital itself is only a means, a device, a tool. The hospital

is not an objective or end in itself. The hospital does not exist for the benefit of its departments. Everyone must recognize this basic fact: The whole exists to serve sick people present and future.

In order to provide effective service, a producing department must know what is wanted and when it is needed. A requesting department must know what is possible and what is reasonable and the two must educate each other to recognize the unavoidable limitations of time, equipment, and money. Good manners, sincerity, concise explanations, willingness to go halfway or more, and ability to read doctors' minds in addition to technical skills are the things which are important.

Unreasonable demands, arbitrary judgments, tactlessness, and impatience are the enemies of good relationships.

The medical photographer must educate his customers concerning limitations: the difference between effective photography and poor photography. Education requires patience and that rare ability to be silent when words are uncalled for. The medical photographer must be ready to suggest at the right time and place ways to make photography more useful and effective. All of which means that the medical photographer, in addition to a store of knowledge of anatomy and medical terms and in addition to a store of technical skills, must be the kind of person who instills confidence in others. This is something that cannot be commanded or demanded. It can only be earned by a calm patience, a pleasant manner, and competence

The Medical Photography Unit should not be "low man on the hospital totem pole" but cannot expect to be high man either. It fits in whatever way is best into the individual hospital organization as a part of the education in the organization. For that reason our Medical Photography Laboratory and Medical Art Laboratory are recognized as full departments on a par with Admitting, Social Service, and Physiotherapy, and only one step removed from the Administrator. This is, I believe, of some importance because lack of recognition and remoteness from policy making tend to breed what the psychologists call insecurity reactions — aggressiveness, stubbornness, defensiveness, and unhappiness.

The financial relationships are of only secondary importance in determining the success of a department. Some individuals work better under one plan, others work better under another. Regardless, however, of where the money comes from to support a Medical Photography Department, it is very helpful to have some objective method of evaluating the work of the department. This never gives the complete answer, but it does give a dependable point of reference.

There should be a schedule of charges for all photography work and a charge in accordance with that schedule should be recorded for all work done. The relation between gross earnings of the department and the cost of the department is important for any administrator to know. The schedule of charges should be revised from time to time in accordance with policy and experience. If earnings exceed cost by too much, charges should be lowered or the costs should be increased by purchase of new equipment or salaries increased to recognize greater productivity. If costs exceed earnings by too much, charges should be increased or costs reduced or, if productivity is low, perhaps more utilization through better salesmanship. Steady growth in volume of work is a partial measure of customer satisfaction. Lack of growth in volume is a possible indication of something wrong. If this accounting information is not made available to the Department Head and the Administrator, misunderstandings are apt to arise because each will be talking about something different.

The charges should bear some reasonable relation to the time and skill required, but since the types of work are so variable, it is usually impossible to develop valid averages and reasonably informed guesses have to suffice Special demands warrant special charges And sometimes penalty charges may be necessary to deal with unreasonable demands.

The department should be expected to operate on a budget which is prepared and recommended by the head of the department, subject to review and adjustment in conference with the Administrator. Once a departmental budget is approved, which is a plan of action for the coming year, then the Department Head, the Chief Photographer, should go ahead and run his department accordingly and leave the Administrator free for a few of his other concerns.

A department which keynotes service, keeps its eye on the main objective of better health, and in which all of the people, in addition to being technically competent, are big people, will be successful beyond all imaginings.

BOOK REVIEWS

COLOR DIGEST, *Higgins Ink Co., Inc., 271 9th St., Brooklyn, N.Y., 39 pages (1953), 8½ in. x 11 in., plus complete cards for constructing an Ostwald Solid, $2.00.*

For the photographer who wants to have a fuller understanding of color and color phenomena this book is just about ideal. The text is written in simple language and anything that borders upon being technical is so well illustrated that there is little doubt but that the reader will grasp the subject matter. The book starts out with a chapter entitled "Subjective Color" and nicely presents the relationship between physiology and color and discusses many aspects of the psychology of color. In subsequent chapters the physical aspects of color are treated and the basic principles of spectrophotometry are simply explained. Various methods of color mixture are discussed and the Ostwald system of color specification is thoroughly reviewed. Various visual color effects are described and nicely illustrated. The Munsell System for color specification is compared to the Ostwald system and the publishers explain in some detail why they felt justified in adopting the Ostwald method as a basis for their book. The principles of color harmony are also outlined and the applications of the Color Harmony Manual of the Container Corporation of America are described. Inserted in the back of the book are twelve heavy paper plates for producing a complete Ostwald Solid. Full instructions are given for constructing the solid.

THE PRINCIPLES OF LINE ILLUSTRATION, *L. N. Staniland, Harvard University Press, Cambridge 38, Mass., 212 pages (1953), illustrated, 5½ in. x 8¾ in., $5.00.*

The biological photographer and artist will find much of interest and value in Mr. Staniland's new book. It is slanted particularly to the requirements of biological and other scientific workers. In addition to the introduction, appendix, summary and index, the book has five principal chapters entitled in order, "Techniques in Line Drawing", "Aids to Accurate Drawing", "The Use of Colour", "Graphs, Diagrams and Maps", "Some Help With Lettering".

The author sets out with the premise that even the roughest drawing may save many words. He believes that a simple drawing, consistent with full and accurate information, serves a purpose for the scientist out of proportion to the effort required to learn how to make adequate drawings. He shows clearly, step by step, how anyone can make useful, presentable drawings, and why the worker should not take refuge in the statement "I can't draw" when he is asked to include such illustrations in preparing material for publication.

The book is about as simple and practical as an author could make it. Nevertheless, it is thorough and serious in content, and should teach any interested worker how to execute satisfactory biological drawings. The printing of the book in Great Britain probably explains why the word "color" is spelled "colour" throughout the text.

DIRECTORY OF 2,660 16 mm FILM LIBRARIES, *U.S. Government Office of Education, U.S. Government Printing Office, Superintendent of Documents, Washington 25, D.C., 172 pages (1953), 50c, Catalog No. FS5.3:953/7.*

This directory of 16mm film libraries was compiled for the use of teachers, school administrators, librarians, and others who have a need for motion pictures in educational and informational programs. It actually is a revision and an expansion of a previous publication entitled "A Directory of 2,002 16mm Film Libraries" prepared and published two years ago. The directory is annotated and is arranged by states and cities

THE OPTICAL INDUSTRY DIRECTORY, *Edited by E. S. Tuttle, Optical Publishing Co., Huntington, L.I., N.Y. (1954), 8 in. x 10½ in., $5.00.*

This very comprehensive directory of the optical industry contains five separate sections, each separately paged. The first section gives a full list of manufacturers, distributors and designers of American optical supplies. The second section concerns foreign optical manufacturers, the third section gives a full listing of classified products, the fourth section a listing of personnel in the optical industry, and finally a listing of advertisers who appear in the book. To compile the information given, the editors sent questionnaires to 3,500 American optical manufacturers. The listing of foreign manufacturers is not as complete as for American manufacturers, but there are 360 foreign firms dealt with. The book is a most valuable reference source for those who have occasion to order or have made especially for them almost any type of optical device or single optical component.

CONVERSION TABLES, *Carl H. P. Pepjung, Grossdruckerei, H. M. Hauschild, Bremen, Germany, 234 pages (1952), 4¼ in. x 5¾ in., $2.00.*

This book contains 76 very extensive conversion tables published both in German and in English. The material is very clearly presented which makes for easy use and ready reference. The tables include monetary conversions, equivalents of various dimensions (lengths, weights and measures, etc.) power, energy and heat conversions, comparisons of pipe flanges, wire sizes and screw threads, and various miscellaneous conversion tables.

A SERIES OF BOOKLETS ON METHODS AND TECHNIQUES FOR THE GRAPHIC ARTS, *U.S. Government Printing Office, Superintendent of Documents, Washington 25, D.C., various prices and various dates.*

From 1950 to the end of 1953 the U. S. Government Printing Office has published a total of 13 booklets on various phases of graphic arts methods and techniques. This publishing program has resulted from a joint research project conducted by the Government Printing Office and the Printing Industries of America. The prices for the booklets range from 10c to 45c, with the single exception of the Government Printing Office Style Manual which costs $2.50. Since photographic illustrators are frequently engaged in book and periodical publication problems it is worthwhile to keep abreast of new work being done in the graphic arts fields. Not all of the titles, however, will be of any particular value to photographers. A complete list of the 13 booklets can be obtained by writing to the Superintendent of Documents in Washington.

HOW TO TAKE BETTER PHOTOGRAPHS, *Edited by Betty M. Kanameishi, Popular Mechanics Co., 200 E. Ontario St., Chicago 11, Ill., 160 pages (1954), 6½ in. x 9½ in., $2.50.*

Although this is a popular treatment containing eight chapters directed toward the improvement of amateur picture taking results, there are numerous "how-to-do-it" hints that would be of value to photographers at any level. The book is profusely illustrated but since it was printed by offset lithography the photographs sometimes suffer in quality.

RECOMMENDED BOOKS ON AUDIO-VISUAL EDUCATION, *William Lewin, Audio-Visual Guide, 1630 Springfield Ave., Maplewood, N.J., 8 pages (1954), 8½ in. x 11 in., 25c.*

This is a list of 116 books on various aspects of audio-visual education. In each case the publisher's name and address and price of the book are given. The author admits that a complete library on all audio-visual techniques and applications would run to around 1500 volumes. Nevertheless, he considers the up-to-date list of 116 titles as representative of the literature available for this field.

PROTECTING THE PUBLIC HEALTH, *E. I. du Pont de Nemours & Co., Wilmington, Del., 32 pages (1954), 9 in. x. 12 in., no charge.*

This is a very thoroughly illustrated booklet which serves as an excellent example of the value of photography in forcefully presenting a subject. The booklet presents the story of Du Pont's activities in supplying chemicals for promoting better public health. For this reason attention is focused mostly on the Haskell Laboratory of Toxicology and Industrial Medicine, operated by Du Pont in their new building at Newark, Delaware. The book was obviously prepared and published for industrial propaganda. It is very illuminating and well worth reading. It is evident that the Du Pont company is a great believer in using photography to get across a message.

MARINE TROPICALS, *Ed L. Fisher, Sub-Marine Studios, 918 Langford Bldg., Miami 32, Fla., 56 pages, 5½ in. x 8½ in., $1.50.*

For many years Mr. Ed Fisher has been photographing, collecting and writing about life under the sea. His diving experience started in California but soon carried him to the tropical waters of Florida where he explored the ocean bottom from the shallows of reefs to more than 200 feet below the Gulf Stream. The photograph reproduced below, taken by Jerry Greenberg, shows the author at work in the depths of the sea. The book contains twelve main chapters, plus a bibliography and appendix. Unfortunately for photographers the book is chiefly concerned with the collection of marine specimens and their live preservation. Practically nothing is given on photography under the sea.

PHOTOGRAPHY: THEORY AND PRACTICE, *L. P. Clerc, edited by A. Kraszna-Krausz, Pitman Publishing Corp., 2 West 45th St., New York, N.Y., 606 pages (1954), illustrated, 7½ inches x 10 inches, $15.00.*

The venerable author of this book, Mr. L. P. Clerc, although a Frenchman, is well known to American readers through earlier English editions of his "Photography: Theory and Practice". This new edition is the third English edition, bringing the book completely up to date. It required an Editor-in-Chief and 17 collaborators to revise the book which attests the fact that the original author at least touched upon almost every aspect of photography.

Mr. Clerc insists that his work not be considered encyclopedic because he has purposely omitted discussions on obsolete processes and various oddities of photography which have no particular practical value. Nevertheless, if one considers only the subjects treated—and there are hundreds—it is imperative to consider the book encyclopedic in character.

The main body of the book contains 6 parts, each having several chapters. Part 1 concerns the relationship of vision and photography and contains 5 chapters ranging from the definition of light and color to the visual aspects of perspective. Part 2 deals with the nature of the optical image before it is recorded by a photosensitive material. This part has 9 chapters, covering every aspect of optics and camera equipment. The third part has to do with the production of negatives. The very thorough treatment of this subject is indicated by the fact that 21 separate chapters are devoted to it. Part 4 has 12 chapters on printing processes and Part 5 contains 3 chapters that discuss various special techniques. The final section of the book (Part 6) includes three well developed chapters on the overall subject of color photography.

In this new edition the index has been greatly extended over previous editions and is a tribute to the Editor-in-Chief, Mr. A. Kraszna-Krausz. This book is highly recommended in spite of its high price

New Products

NEW KODAK ILLUMINATOR

A new Kodak Transparency Illuminator 7 in. x 9 in. which features particularly good spectral and luminance characteristics, has recently been announced by the Eastman Kodak Company. Both color and brightness characteristics of the new Illuminator have been kept to tight standards, the company states, to achieve proper color balance for viewing color transparencies. It is made of long-lasting, high-impact Styron Plastic sheet with white translucent Plexiglass and a special blue glass filter for proper color correction. It uses a standard 6-watt daylight lamp in the base of the illumination. With six-foot cord and plug, ready for use on 110-220 volt AC or DC, the new illuminator is priced at $14.50 list.

NEW MIDGET FLASH LAMPS

Further sparking the trend to tinier, low-cost, more convenient photoflash lamps are Amplex Corporation's new PF .1 and PF .1M. These are said to be smaller than any other flash lamps of comparable light output. They employ hydrogenium wire elements and can be used with all types of flash cameras. Delivering 5,400 lumen seconds, the PF .1 is designed for all "open flash", fixed focus cameras and for synchronized shots up to 1/100. It has a bayonet base which fits all existing camera equipment without an adapter.

The same flash characteristics are embodied in the new PF .1M which has a new unique miniature base to meet the trend to new small reflectors. The PF .1 is 1¼" long and ¾" in diameter, while the PF .1M is ¾" smaller in height and ⅛" smaller in diameter. Both lamps are priced at ten cents each.

PANON WIDE ANGLE CAMERA

A new super-wide angle Panon Camera covering an angle range of 140 degrees has been announced by Ritz Camera Centers, 619 11th. Street, N.W., Washington 5, D.C. The field an ordinary camera can cover is about only a third or fourth of the normal range of vision. The Panon will cover an effective range of 140 degrees on horizontal pictures and 90 degrees on vertical pictures. It can be used without a

tripod, vertically or horizontally. It takes six 2 in. x 4¼ in. pictures on standard 120 film. The lens is a coated, 50mm f/2.8 Hexanon. Focusing is from 3 feet to infinity. Shutter speeds are from ½ second to 1/200 second. Camera size is 6 inches by 4 inches. Weight is 4 pounds. Price with leather case, $450.00.

NEW DU PONT CINE FILMS

Two Du Pont motion picture films, perforated for high-speed use, are to be offered through Wollensak Optical Company of Rochester, N.Y., under the Wollensak "Fastax" label. The two

films are Du Pont "Superior" 3, Type 927, and High Speed Rapid Reversal Type [illegible], both fast films such as used in newsreel and TV work. "Superior" 3 negative film (125 daylight, 100 tungsten) will be sold in 35mm size only. High Speed Rapid Reversal (160 daylight, 125 tungsten) and negative stock (80 daylight, 64 tungsten) will be available in 35 and 16mm sizes.

NEW DU PONT PRESS FILM

A new, fast, all-purpose "Superior" Press panchromatic sheet film has been released by the Du Pont Company. Faster than Du Pont #428 High Speed Pan (160 daylight, 125 tungsten), "Superior" Press is rated at exposure indexes of 200 daylight and 160 tungsten. Its greater speed is said to be apparent under all types of lighting: daylight, tungsten and flash.

"Superior" Press has not only higher speed, but also a much wider tone-scale and exposure-development latitude than previous Du Pont films. The increased latitude minimizes blocked up highlights and allows greater retention of shadow detail. The wider tone-scale is said to virtually eliminate the problem of burned up highlights, particularly chalky or pasty faces resulting from overexposure by flash.

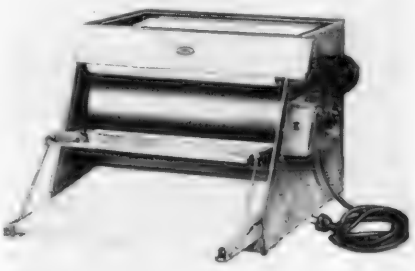
"Superior" Press film is available at popular prices at photo supply shops in the following quantities and inch sizes: 4 sheet boxes 2 x 2, 3 x 4, 4 x 5, 5 x 7 and 8 x 10; 25 sheet boxes 4 x 5 and 5 x 7.

NEW CLOSE-UP DEVICE FOR ANSCO KAROMAT CAMERAS

Most users of Ansco Karomat Cameras will be interested in the Karomat Proximeter, a new accessory for simplifying the camera to subject photography. The Ansco Proximeter simplifies the making of close-up pictures by permitting rangefinder focusing at extremely short subject distances. It consists of a close-up taking lens and a matched viewing lens, mounted as a single unit. The taking lens fits over the camera lens of the Karomat, the viewing lens over the camera's combination rangefinder-viewfinder. With the Proximeter in position the camera's coupled rangefinder-viewfinder focuses the camera and shows the correct field of view at the same time. The device is useful for copying and for making close-ups of flowers, insects, materia medica, printed matter, technical photographs of machine parts, textiles and similar subjects.

There are two models of the Ansco Proximeter. Proximeter I allows rangefinder focusing and corrects the field of view for camera-to-subject distances of 19 to 40 inches. With the Ansco Proximeter II the working distances are 13 to 20 inches. Both Proximeters may be used together, at camera-to-subject distances of [illegible] inches. Price of each $[illegible].

FEDCO #400 DRUM DRYER



Fedco Products, 37 Murray Street, New York 7, N.Y., have introduced a new seamless drum drier which handles either glossy or matte papers. It has a capacity of [illegible] in. x [illegible] in. single weight prints an hour, and takes prints up to 30 inches wide. The drier occupies a floor space of 16 inches by 14 inches and is 15 inches high. It operates on 115 volt AC, and weighs 26 pounds. Price available from the manufacturer.

NEW ZEISS IKON CONTAFLEX CAMERA ANNOUNCED

Carl Zeiss, Inc., 485 Fifth Ave., New York 17, N.Y. announces a new single lens reflex camera for 35mm film. It carries the well known trade name of CONTAFLEX, although it is radically different from the previous twin-lens,

mirror-reflex camera of the same name. Of special interest is that the ground-glass viewing screen embodies both ground-glass and range-finder focusing. A special penta, roof-type prism at the top of the camera makes eye-level ground-glass focusing possible and, at the same time, range-finder focusing in a practical, positive manner, thus assuring simple and quick focusing for critical sharpness.

The Contaflex comes equipped with the Zeiss Tessar f/2.8, 45mm focal length lens. The Synchro Compur (MX) shutter has flash and strobe synchronization built in for the entire range of shutter speeds from 1 to 1/500th second.

The camera has a completely removable back for quick film loading and cleaning, the ability to accommodate not only standard 35mm film cartridges but also Contax film cassettes (by means of which film re-winding after exposure becomes unnecessary). a knurled film-transport and shutter-winding knob which also incorporates the shutter release button, etc. The Contaflex has an automatic lens [illegible] which [illegible] with the lens wide open. When the shutter release button is pressed, the lens diaphragm automatically closes to the stop value for which it was preset.

The Contaflex [illegible] to the [illegible] as well as to [illegible] photographers, scientists and other professional workers who require parallax-free and accurate composing and focusing through the same lens that records the picture. By means of Proxar supplementary close-up lenses, objects as close [illegible] may be photographed with assurance that what is seen on the ground-glass will be recorded on the film. The camera is priced at $169.00. The Eveready case is $12.50 additional.

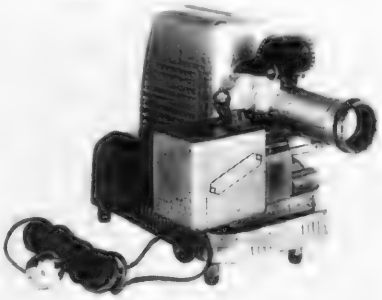
NEW ANSCO CAMERAS

Ansco, Binghamton, N.Y. has announced the addition of four new cameras to its camera line. The cameras will reach the market during April, May and June.

The Ansco Memar camera is priced at $49.95 and is aimed at the beginning photographer. A feature of this new camera's design is a sliding front panel which is inter-connected with a folding light shield for the viewing lens. One quick sliding motion raises the front panel and erects the finder hood, readying the lenses, but protecting them when not in use. The Ansco Memar is priced at $49.50. One of the Memar's most interesting features is a new thumb-lever film transport which, in one motion, automatically sets the exposure counter, actuates the double-exposure preventer, advances the film and sets the shutter for the next picture. The third new camera is the 35mm Ansco Super Regent, with lens-coupled rangefinder, new four-element f/3.5 anastigmat lens, 1/500 second Synchro-Compur Shutter and various other miniature camera features. The Super Regent sells for $89.50. The new Ansco Super Speedex f/3.5 camera is said to be the world's first fully [illegible] camera. It sells for $134.50.

NEW FILMSTRIP ADVANCE

Viewlex Inc. 35-01 Queens [illegible] Island City, N.Y., has just introduced the Strip-O-Matic, a remote control filmstrip advance mechanism. The mechanism is operated from a hand-held push-button remote control unit. It is designed for use only with Viewflex projectors, and is said to embody a completely new departure in remote control advance mechanisms. A small clutch-motor is used instead of a solenoid. Price, $39.50.



NEW DU PONT X-RAY FILM

A new ultra-fine grain industrial x-ray film has been announced by the Du Pont Photo Products Department. Known as Type 510, the film can be used at low voltages (10-20 peak kilovolts) to examine [illegible] quality welds in aluminum, magnesium, etc., and wheat. With million-volt x-ray or betatron equipment, it may be used to examine steel up to three inches in thickness. The new film is said to be of particular advantage on subjects where very minute detail is sought since the fine-grain emulsion permits detection of tiny flaws in, for example, spot-welding in aluminum sheeting. The same is true for

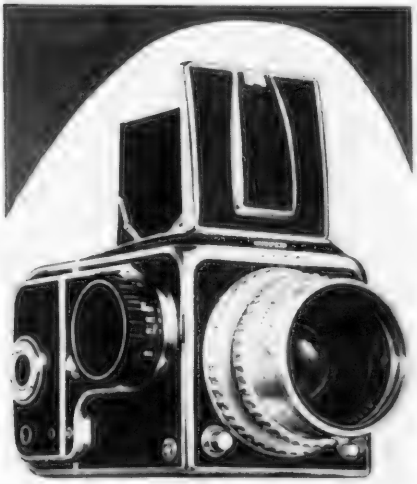
the detection of foreign contamination in grain [illegible] a relatively new use for x-rays.

The new film is only approximately one-third as fast as Du Pont Type 506 Industrial X-Ray film. Type 510 is designed for use without calcium-tungstate intensifying screens. It is available in all standard sizes and is packaged as "NIF" non-interleaved film. "NIF" packaging eliminates the paper separators between individual pieces of film, thus simplifying the loading of holders for exposure.

NEW MODEL HASSELBLAD

The new model Hasselblad [illegible] x 2¼ in. Swedish reflex camera is being marketed by Williouahbys, 110 W. 32nd Street, New York 1, N.Y. It is a single lens reflex camera, with speeds from 1 full second and [illegible]

Interchangeable roll film magazines permit fast change-over from color film to black and white, from high speed to slow speed films. Film transport and automatic shutter setting are accomplished by a single control knob. The hood is removable to facilitate cleaning of



[illegible] special Hasselblad hood. The patented aperture pre-selector permits full aperture focusing simply and quickly. There is a parallax-compensating sportsfinder with built-in flash contact. [illegible] Price, $399.50.

NEW PHOTOFLASH BATTERY AVAILABLE

Buttafarri Corporation of New York, sole [illegible] Ferrania and Galileo of Italy, announce that they are now marketing their type photoflash battery of the Continental standard size. It is a two cell 3 volt battery in a single sleeve, equivalent in dimensions to Ray-O-Vac #BR-21 and Usalite #999. 13/16" in diameter and 2⅞" long overall. Besides being used in the Ferrania model "A" folding pocket camera, this battery is required for many other [illegible] can be included [illegible] types of [illegible] photographic apparatus. This new battery is known as the "SUPERPILA" No. 66 and retails for 20c.

GAUMOT-KALEE FLUTTER METER

[illegible] Gaumot-Kalee Corporation, [illegible] New York, N. Y. [illegible] announced [illegible] the Gaumot-Kalee Flutter Meter is designed to measure small frequency variations of a given carrier frequency. If the meter is provided with a signal of the correct frequency and of suitable amplitude from a film soundhead for example, then [illegible] recording and/or reproducing machine can be [illegible] The meter [illegible] a [illegible] carrier frequency of [illegible] plus and minus [illegible] and [illegible] the [illegible] measurements to be made on machines that are running off speed, or using films or discs [illegible]

The meter consists of a narrow band amplifier, a limiter, a discriminator and detector, and a metering system, the whole unit being self contained with its own power supplies. The [illegible] with an input control for adjusting signal level,

which must not be less than 100 mV for correct operation.

An amplitude limiter, which eliminates effects caused by signal level variations, is followed by a power amplifier which drives a discriminator operating at a mean frequency of 3 Kc/s. The discriminator may be tuned from 2,850 c.p.s. to 3,150 c.p.s. to accommodate variations in mean carrier frequency. The error in the input frequency expressed as a percentage of speed is indicated on a suitable scale. The input signal level at the discriminator which is set up on a meter by means of a control in the limiter circuit, is maintained constant by the limiter, thus ensuring correct operation and constant sensitivity of the discriminator.

NEW SLIDE CABINET

The Brumberger Sales Corp. announces the new[illegible] Cabinet, for [illegible] board mounted slides are filed.

The #1097 is of all-steel streamlined construction, grey hammertone finish. Each of its six [illegible] spacers keep each slide independently in a vertical position. [illegible] stacked and bolted together. Overall dimensions are 15½" wide, 9" deep, 19" high.

CEBE-2 PERMAFLASH

The [illegible] Salle Street, Chicago 4, Ill., are the American distributors for the new German-made electronic flashgun with rechargeable, dry cell, known as the CeBe-2 Permaflash. The light output of the unit is approximately 80 watt seconds, with a flash duration of 1/500 second. The recycling time is 5 to 8 seconds. It is stated that 1000 flashes are obtainable without recharging, whereas 3000 flashes are possible by means of the plug-in plug-out recharging system. Complete data sheets are available from the distributors.

OMAG POCKET MICROSCOPES

Karl Heitz, Inc., 150 W. 54th Street, New York 19, N.Y. are importing three compact Swiss-made pocket microscopes for science and industry. Magnification range is from 10 up to 50 times. Built-in illumination allows objects to be examined without [illegible] preparation. Dry cell batteries or step-down transformer for regular electric light circuit can be used. Leather carrying case, different eyepieces, and base plates for various objects are available. Prices: Mikro 25 (10-25 x), $22.50; Mikr[illegible] x), $24.9[illegible].

NEW CAMERA CASE WITH BUILT-IN FLASH UNIT

[illegible] N.Y. [illegible] for the Voigtlander 'Prominent' 35mm camera

When closed, the case looks like any other, but when open, one compartment has a B-C flash unit, whereas the other compartment holds the flash reflector. Other models for other cameras are expected in the future. Price, $29.9[illegible]

Your Association

A section of the Journal devoted to official announcements, chapter events, and other matters of historical significance to the Association.

CHAPTER EVENTS

Warren Sturgis, Chairman, Chapters Committee

Boston: February 3, Bob Uhlrich, of the Pratt Diagnostic Clinic, talked on "Print Quality for the Engraver", and demonstrated various airbrush techniques

Chicago: November 24, Mr. H. H. Gibson, Staff Photographer of the Illinois Central Railroad, discussed the subject: "Understanding Photochemistry." On December 15 this Chapter held its Annual Christmas Dinner and enjoyed Avis Gregersen's motion picture, "Christmas in Southern California." At the meeting on January 19 Wolfgang Zieler demonstrated "Aligning Photomicrographic Equipment," and on February 16 Mr. George Schectman, of Paillard Products, Inc., discussed the Bolex Stereo-System, illustrating his talk with a film. March 16, an extensive talk on Color Film, its manufacture, physical properties, and use, was given by Mr. Edward Chase, of the Chicago Branch of Eastman Kodak Co

New York: November 19, a "Clinic on Color Photography and Processing" was presided over by Robert S. Crandall and Virgil R. Cheek, of Robert Crandall Associates, Inc., who presented a film, "Cerebral Palsy", in addition to answering members' questions concerning color problems. "A Preliminary Demonstration of 3-D Cinefluorography" was the title of the film presented on December 17 by Leo L. Leveridge, M.D., of Pfizer Laboratories, Inc. The new method of achieving the stereoscopic effect by photographing the patient while he is being rotated, and then projecting two alternate frames simultaneously, was explained by Dr. Leveridge. Dr. Roman Vishniac, member of this Chapter well known for his story illustrations in national magazines, spoke on January 21 about his work in connection with his most recent assignment for LIFE magazine. On February 25, Sam Dunton, famous animal photographer for the New York Zoological Society, spoke on "Biological Photography and its Application at the Bronx Zoo." Several films were shown, among them Mr. Dunton's unusual "Locomotion of Snakes", in which the actual means of this locomotion is proved by cinefluorography. The meeting on March 25 was devoted to the subject of Industrial Photography; Ted Czarda, Chief Photographer for the Johns-Manville Research Center, was the speaker.

Northern Ohio: Although not reported recently, this Chapter has held monthly meetings, except for July, many of which have been of an informal nature, and designed to effect a reorganization on a basis of wider interest to the membership. The meetings during recent months have been at different hospitals in the Chapter area. On September 18 a demonstration on phase photomicrography was given at the Akron City Hospital. October 16, a film on "The Life of the Harvester Ant" was shown to members at St. Vincent's Charity Hospital, Cleveland, and on November 19 at Cleveland City Hospital Dr. H. E. Kretchmer, Chief of Anesthesiology, spoke on "Explosive Characteristics of Anesthetic Agents" in which he suggested that the BPA could set up valuable standards for safety during photography in the operating room. A business meeting was held on January 14

Rochester, N. Y.: November 17, Donald J. McDill, of Eastman Kodak Co., presented a paper entitled: "Some Photographic Hints." For the January 19 meeting several members from Buffalo were invited to discuss "The Status of Medical Photography in the Buffalo Area." Mr. Melford Diedrick, Director of Medical Illustration at the University of Buffalo, led off with an exposition of problems concerned with preparation of slides; Mr. Harold Baitz, of the Veterans Hospital, showed a film describing his specially designed equipment for macrophotography. Mr. Lee Bowerman and Miss Mary Cooros, recent graduates of the School of Medical Photography at Rochester General Hospital, discussed the necessary adaptation to new conditions and changed attitudes when a former student first finds him-

self in charge of a department of medical photography. On February 16 Chapter members met to review and select prints for the BPA Permanent Collection from the recent Travelling Salons, and on March 16 Robert T. Morrison, of Eastman Kodak Co., spoke on "The Microfilming of Radiographs".

Southern California: The following series of interesting and varied program subjects at meetings of this Chapter is commended to the attention of all Program Committees: November 19, "The Theory of the Electron Microscope" by Mr. Douglas Upton; December 17, "Photography of Tropical Fish", by Mr. Gene Wolfsheimer, plus "Some Xmas Fun — Photographic Charades"; January 21, two films "Wonders of Plant Growth" and "Wonders of the Desert", time-lapse footage shot and discussed by Mr. Steve Craig; February 18, "Underwater Motion Pictures" presented by Dr. Nelson Mathison; three E. K. Co. developments demonstrated and discussed by Lloyd Matlovsky, "Kodak Autoscreen Film", "Ektagraph Silk-Screen Film", and "Alum-o-lith Presensitized Litho Plates". The March announcement carried the unhappy announcement that hard-working Secretary Avis Gregersen has been forced to resign her position because of ill-health. BPA members the country over will surely wish her a speedy recovery.

Texas: The fall meeting of this Chapter was held on September 12 at the Methodist Hospital in Dallas. Highlights were as follows: a paper on "Techniques and Use of Ektacolor Film and Ektacolor Print Film" by Mr. Gene Farren, of Photocolor Laboratories of Houston; a demonstration of RCA magnetic sound equipment by Mr. Earl Bauer, of Bauer's Audio-Video in Dallas; a talk on the status of color television for hospital use by Chapter Chairman Robert Kolvoord; a demonstration of portable display units and their construction, by Mr. Walter Webb, of the M. D. Anderson Hospital in Houston; a report on the 23rd Annual BPA Meeting by Mr. Leroy Winburne, of Temple. A buffet supper sponsored by the Southwestern Films Laboratory and the Lone Star Camera Exchange closed the meeting. On March 19-20 a full-scale "Motion Picture Workshop" covering medical and scientific 16mm. film production was held in Houston. A full report on this outstanding enterprise will be given in the next issue of the Journal.

Upper Midwest: The most recent issue of this Chapter's "Photo News" gives the program for the spring meeting, held at the Radisson Hotel, Minneapolis, on March 20-21. The papers included: "The Use of Magnetic Recording in Motion Pictures" by Mr. Richard F. Dubbe and Mr. Andrew Tersoon, of the Magnetic Products Labortory of Minnesota Mining and Manufacturing Co.; "Problems in Color Photography" by Mr. Charles Burgess, of Burgess Photographic Studio, Minneapolis; "Mutual Problems of the Medical Illustrator and Medical Photographer," by Mr. Robert Venassi, Medical Illustrator, Minneapolis; "A Need for Medical Photographs" by Mr. Mark Parker of Modern Medicine magazine; "Microscopy of Minerals and Metals" by Dr. S. B. Cooke, Professor of Metallurgy, University of Minnesota; "Problems Encountered in the Production of Wild Life Films" by Professor W. J. Breckenridge, Director of the Museum of Natural History, University of Minnesota. In addition to a special program of entertainment for wives and other guests, a cocktail hour, sponsored by Century Radio and Camera Shops, and a dinner meeting were also held

Wisconsin: This Chapter was officially welcomed into the BPA on January 22, as a result of the presentation of its Constitution and a slate of the following officers, selected at its organization meeting: President—Mr. Michael Maradik; Vice-President — Mr. George W. Spuda; Secretary-Treasurer — Mrs. Betty J. Spuda. The BPA is looking forward to being guests of this, our newest Chapter, at the 25th Annual Meeting. Mr. Leo C. Massopust has announced that the dates for this will be August 30-September 2, 1955; it will be held at Hotel Schroeder, Milwaukee.

24TH BPA ANNUAL MEETING

Final arrangements for the 24th Annual Meeting of the Biological Photographic Association are progressing rapidly. A full schedule of technical papers and social events, as well as the annual salon, special exhibits and extensive commercial exhibits are being planned.

PLACE — CHALFONTE-HADDON HALL
Atlantic City, New Jersey

DATES — AUGUST 25 TO 27, 1954

General Chairman —

WILLIAM J. TAYLOR
Temple University Hospital
3401 N. Broad Street
Philadelphia 40, Pa.

Program Chairman —

H. LOU GIBSON
Eastman Kodak Company
343 State Street
Rochester 4, N.Y.

NEW B.P.A. MEMBERS

(Oct. 1953 through Dec. 1953)

Malcolm L. Barberot, New Orleans, La.
Angela Bartenbach, Chicago, Ill.
Kenneth E. Boyer, Battle Creek, Neb.
Henri Brouillette, Cap. Madeleine, Canada
William Byford, Toronto, Canada
F. J. Campos, M.D., St. Louis, Mo.
Dr. George C. Christensen, Ames, Iowa
R. B. Churchill, Los Angeles, Calif.
Robert W. DeVoe, M.D., San Leandro, Calif.
Felix E. Dine, Swampscott, Mass.
Victor T. Elliott, Baltimore, Md.
Eugene J. Gatze, Oakland, Calif.
Robert Geer, New Orleans, La.
Roy Guerra, Havana, Cuba
Donald H. Haug, Chicago, Ill.
Vernon C. Johnson, Salem, Va.
Edward C. Klostermeyer, Prosser, Wash.
Abel A. Lazzarini, Jr., New York, N.Y.
Edward F. Mazur, M.D., Camden, N.J.
Norman E. Menck, Cleveland, Ohio
Dr. Jurgen Meyer-Arendt, Hamburg, Germany
Charles W. Ostrum, M.D., Philadelphia, Pa.
Albert Pegg, Leeds, Yorkshire, England
Ward A. Peterson, M.D., Eugene, Ore.
Richard H. Ray, Duarte, Calif.
Roy L. Sexton, Jr., Washington, D.C.
Victor Schwentker, Brant Lake, N.Y.
Arthur H. Small, Houston, Tex.
Milton R. Smith, Rochester, N.Y.
Betty J. Spuda, Wauwatosa, Wis.
Gordon N. Stagg, Tooele, Utah
Hilary P. Stiff, Newington, Conn.
Charles Trabulus, New York, N.Y.
Donald A. Walch, Waterport, N.Y.
Dr. Clarke B. Walsworth, San Pedro, Calif.
Lawrence R. Whitson, Jr., Chicago, Ill.
Clarence Williams, Kirksville, Mo.
Tats Yamamoto, Edmonton, Canada

For Information Concerning Membership in the Biological Photographic Association, Write the Administrative Secretary, 533 W. 57th Street, New York 19, N. Y.

CONTRIBUTING MEMBERS

Allan J. Allston
Harold C. Baitz
Dr. Edgar C. Baker
A. V. Banones
Earl C. Bartlett
Edna Campbell Barker
Malcom L. Barnes, M.D.
S/Sgt. R. T. Barrus
Oscar J. Becker, M.D.
John J. Beiter
Tibor Benedek, M.D.
Rush Maxwell Blodget, Jr., M.D.
Percy W. Brooks
Adrian T. Brothers
Laurence B. Brown
Robert A. Brown
C. G. Brownell
James E. Brubaker
Joseph D. Brubaker
Cora T. Burgess
Jasper D. Bush, Jr., M.D.
Maurice O. Button
William J. Cameron
William H. Campbell
Julian Carlile
Herman R. Chandler
John E. Colburn
Philip A. Conrath
Harold B. Davidson, M.D.
Marian K. Dawes
C. G. de Gutierrez-Mahoney, M.D.
Edward Drewello
P. K. Duraiswami, M.D.
C. Graham Eddy
Dr. Edmond J. Farris
Deam H. Ferris
Louis Paul Flory
A. Wilson Footer, M.D.
Jay T. Fox
Larry Gaskins
John A. Gaughan
Boas E. Gibson
H. Lou Gibson
Luther R. Gilliam
Jane K. Glaser
D. M. Glover, M.D.
Gerald A. Gombert
Rev. A. J. Grant
Alex A. Gravesen
Bruce Gray
Avis Gregersen
Richard D. Grill
Edward Hamilton
Ferdinand R. Harding
Hal B. Hayes
Rudolph J. Henning
Leslie E. Hier, Jr.
David Hilbrand
Charlotte S. Holt
Nathan S. Horton
Wayne M. Hull, M.D.
Richard Hyll
Maria Ikenberg
John L. Isbister, M.D.
Joseph T. Jackson
Myrtle E. Johnson
Nathan C. Kantor
Leonard A. Julin
Rita Pauline Kelly
Victor R. Landi
John M. Langton, M.D.
Thomas J. Lannon
Mervin W. LaRue, Sr.
James H. Law
Pierre J. LeDoux
Henry M. Lester
Albert Levin
K. Cramer Lewis
Gerald M. Lindley
R. P. Loveland
Don Loving
Richard Malcomson
Robert Mallory III, M.D.
William L. M. Martinsen
G. E. H. Mathes
Ervin W. Miller
Joseph Edward Mineo
Clark Moore, Jr.
Henry W. Morris
Bert E. Newkirk, Jr.
Merwyn C. Orser
Edgar J. Pagé
Harry W. Parker
Ann G. Pass
William E. Perry
Leonard Perskie
Henry F. Pickett
Robert G. Polk
Inez Porter
Dr. Arthur W. Proetz
Dr. William Quijano
S. M. Rabson, M.D.
Chester F. Reather
Charles G. Reiner
George W. Reis
Joseph H. Reno, M.D.
Louise Retherford
Rose M. Reynolds
Dr. Oscar W. Richards
Dr. Edward W. Robbins
Dr. George L. Royer
Frank Rustander
Robert A. Sage
Lucien R. St. Laurent
Max Scheerle
Dr. Richard C. Schiller
Anne Scott
Sidney Shapiro
M. Vincent Sheehan
Anne Shiras
Paul J. Showstark
Dr. Fred Sielaff
Stanley D. Simmons
David M. Snaddon
George W. Spuda
William Stevenson
Joseph M. Strong, M.D.
Calvin L. Stucker
Warren Sturgis
Lewis J. Sunny
Cyril T. Surington, M.D.
Wilson A. Swanker, M.D.
William J. Taylor
Dr. Harvey E. Thorpe
Howard T. Toenniges
Harris B. Tuttle
Masaru Uehara
Lloyd E. Varden
Leon M. Vincent
Lewis A. Waerner
Charles Walcott
Julius Weber
Samuel Weiss, M.D.
Laurence R. Whitman
Frank S. Wilbar
Leonard Winograd
Lloyd A. Wolf
Thomas L. Wood
Verlin Y. Yamamoto
Stella Zimmer

SUSTAINING MEMBERS

AMERICAN SPEEDLIGHT CORPORATION
ANSCO
BURLEIGH BROOKS COMPANY
CORECO RESEARCH CORPORATION
ELGEET OPTICAL COMPANY
GAMMA INSTRUMENT COMPANY
W. J. GERMAN, INC.
GRAFLEX, INC.
HARRISON & HARRISON
MEDICAL PRESS, INC.
PAILLARD PRODUCTS, INC.
POLAROID CORPORATION
SILGE & KUHNE
W. M. WELCH MFG. CO.

FELLOWS of the ASSOCIATION

JOHN J. BEITER
PERCY W. BROOKS
LAURENCE B. BROWN
JULIAN CARLILE
LARDNER A. COFFEY
RALPH P. CREER
C. GRAHAM EDDY
DR. EDMOND J. FARRIS
LOUIS PAUL FLORY
JAY T. FOX
ARTHUR W. FUCHS
H. LOU GIBSON
AVIS GREGERSEN
ALLEN HANCOCK
DR. PETER HANSELL
FERDINAND R. HARDING
JOSEPH B. HAULENBEEK
NATHAN S. HORTON
MARIA IKENBERG
LEONARD A. JULIN
MERVIN W. LaRUE
PIERRE J. LE DOUX
HENRY M. LESTER
ALBERT LEVIN
ROGER P. LOVELAND
DAVID LUBIN
ADOLPH MARFAING
WILLIAM L. M. MARTINSEN
LEO C. MASSOPUST
JOHN A. MAURER
STANLEY J. McCOMB
HENRY M. MORRIS
WILLIAM F. PAYNE
LEONARD L. PERSKIE
DR. ADRIANUS PIJPER
DR. ARTHUR W. PROETZ
CHESTER F. REATHER
DR. OSCAR W. RICHARDS
MAURICE N. RICHTER, M.D.
HENRY ROGER
DR. GEORGE L. ROYER
FRANK N. RUSLANDER
ALBERT SADLER
ROBERT A. SAGE
SIDNEY SHAPIRO
ANNE SHIRAS
WILLIAM STEVENSON
WARREN STURGIS
WILLIAM J. TAYLOR
HARRIS B. TUTTLE
LLOYD E. VARDEN
VERLIN Y. YAMAMOTO
STELLA ZIMMER

FELLOWSHIP PROCEDURE

Members may propose for Fellowship in the BPA other members whom they consider worthy of recognition. To be eligible for Fellowship a candidate must have been a member of the Association for five consecutive years and must possess one or more of the following qualifications:

Superior craftsmanship in still or motion picture photography of biological subjects. Ability in photographic research in new methods or materials.

(These require submission of evidence.)

Meritorious contributions to biological photography overall through sustained organizational work.

Two sponsors are required. The sponsors should be well acquainted with the candidate's work and should be ready to furnish the Board with details of his experience and achievements. Those who wish to sponsor a member whom they believe to be eligible should request a Fellowship Application form from the Secretary of the Fellowship Committee: Miss Anne Shiras, Photographic Department, Magee Hospital, Pittsburgh 13, Pennsylvania.

CONTENTS

JOURNAL OF THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

Volume 22, Number 1 — February, 1954

IMAGE DISTORTIONS WITH ILLUMINATION AT SMALL ANGLES OF INCIDENCE — PART I . . . . . Charles Hale 1

IMAGE DISTORTIONS WITH ILLUMINATION AT SMALL ANGLES OF INCIDENCE — PART II . . . . . Charles Hale 7

THE USE OF POLARIZED LIGHT IN THE PHOTOGRAPHY OF UNSTAINED HISTOLOGICAL RADIO AUTOGRAPHS OF PLANT TISSUE . . . Robert F. Smith 15

USING THE SPEEDLIGHT IN ENTOMOLOGY . . Leland R. Brown 17

TELEVISION AND THE MEDICAL ILLUSTRATOR . Philip A. Conrath 22

THE STANFORD RESEARCH INSTITUTE AEROSOL CAMERA . . . . . E. J. Wiggins, E. Robinson, and D. H. Hutchison 26

CONTENTS OF MEDICAL AND BIOLOGICAL ILLUSTRATION 30

PLANNING THE RADIOGRAPH COPY NEGATIVE . William E. Perry 31

HOSPITAL AND MEDICAL PHOTOGRAPHY . Philip D. Bonnet, M.D. 34

BOOK REVIEWS . . . . . All reviews by the Editor 37

NEW PRODUCTS 40

YOUR ASSOCIATION 45

24TH BPA ANNUAL MEETING 47

NEW BPA MEMBERS 47

CONTRIBUTING MEMBERS 48

SUSTAINING MEMBERS, FELLOWS OF THE ASSOCIATION, FELLOWSHIP PROCEDURE . . . . . Inside Back Cover

PRINTING BY HAMMERSMITH-KORTMEYER COMPANY, MILWAUKEE, WISCONSIN